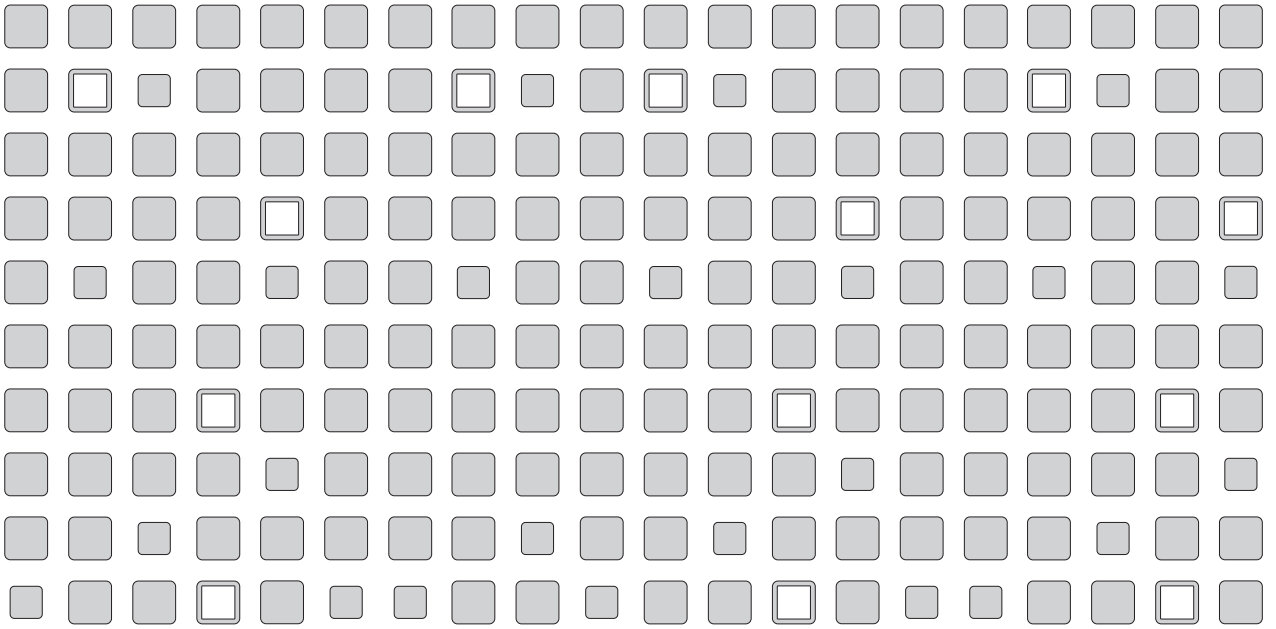
VERSION 2.1

ESX Server™ 2

Mainframe-Class Virtual Machines for the Most Demanding Environments

Administration Guide



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CHAPTER 1

Introduction to VMware ESX Server

This *VMware ESX Server Administration Guide* provides information on how to use VMware ESX Server™ once it has been installed. For information on installing ESX Server, refer to the *VMware ESX Server Installation Guide*.

This chapter contains the following sections:

- VMware ESX Server System Architecture on page 22
- Using VMware ESX Server on page 29

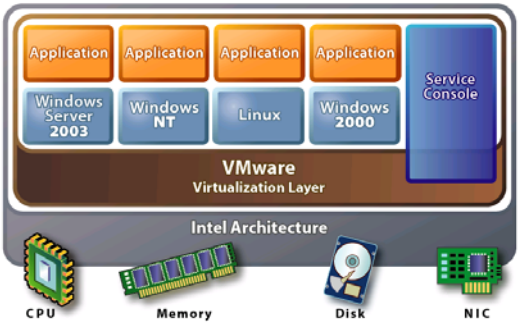
VMware ESX Server System Architecture

VMware ESX Server incorporates a resource manager and a service console that provides bootstrapping, management and other services.

The design of the ESX Server core architecture implements the abstractions that allow hardware resources to be allocated to multiple workloads in fully isolated environments.

The key elements of the system's design are:

- The VMware virtualization layer, which provides the idealized hardware environment and virtualization of underlying physical resources
- The resource manager, which enables the partitioning and guaranteed delivery of CPU, memory, network bandwidth and disk bandwidth to each virtual machine
- The hardware interface components, including device drivers, which enable hardware-specific service delivery while hiding hardware differences from other parts of the system



Virtualization

The VMware virtualization layer brings hardware virtualization, pioneered on IBM VM/370 and other mainframe environments, to the standard Intel server platform. The virtualization layer is common among VMware desktop and server products, providing a consistent platform for development, testing, delivery and support of application workloads from the developer desktop to the workgroup to the data center.

As with mainframe virtualization, the VMware virtual machine offers complete hardware virtualization; the guest operating system and applications (those operating

inside a virtual machine) can never directly determine which specific underlying physical resources they are accessing, such as which CPU they are running on in a multiprocessor system or which physical memory is mapped to their pages. The virtualization of the CPU incorporates direct execution: non-privileged instructions are executed by the hardware CPU without overheads introduced by emulation.

The virtualization layer provides an idealized physical machine that is isolated from other virtual machines on the system. It provides the virtual devices that map to shares of specific physical devices; these devices include virtualized CPU, memory, I/O buses, network interfaces, storage adapters and devices, human interface devices, BIOS and others.

Each virtual machine runs its own operating system and applications; they cannot talk to each other or leak data, other than via networking mechanisms similar to those used to connect separate physical machines. This isolation leads many users of VMware software to build internal firewalls or other network isolation environments, allowing some virtual machines to connect to the outside while others are connected only via virtual networks through other virtual machines.

CPU Virtualization

Each virtual machine appears to run on its own CPU, or set of CPUs, fully isolated from other virtual machines, with its own registers, translation lookaside buffer, and other control structures. Most instructions are directly executed on the physical CPU, allowing compute-intensive workloads to run at near-native speed. Privileged instructions are performed safely by the patented and patent-pending technology in the virtualization layer.

Memory Virtualization

While a contiguous memory space is visible to each virtual machine, the physical memory allocated may not be contiguous. Instead, noncontiguous physical pages are remapped efficiently and presented to each virtual machine. Some of the physical memory of a virtual machine may in fact be mapped to shared pages, or to pages that are unmapped or swapped out. This virtual memory management is performed by ESX Server without the knowledge of the guest operating system and without interfering with its memory management subsystem.

Disk Virtualization

Support of disk devices in ESX Server is an example of the product's hardware independence. Each virtual disk is presented as a SCSI drive connected to a SCSI adapter. This device is the only disk storage controller used by the guest operating system, despite the wide variety of SCSI, RAID and Fibre Channel adapters that might actually be used in the system.

This abstraction makes virtual machines at once more robust and more transportable. There is no need to worry about the variety of potentially destabilizing drivers that may need to be installed on guest operating systems, and the file that encapsulates a virtual disk is identical no matter what underlying controller or disk drive is used.

VMware ESX Server can be used effectively with storage area networks (SANs). ESX Server supports QLogic and Emulex host bus adapters, which allow an ESX Server computer to be connected to a SAN and to see the disk arrays on the SAN.

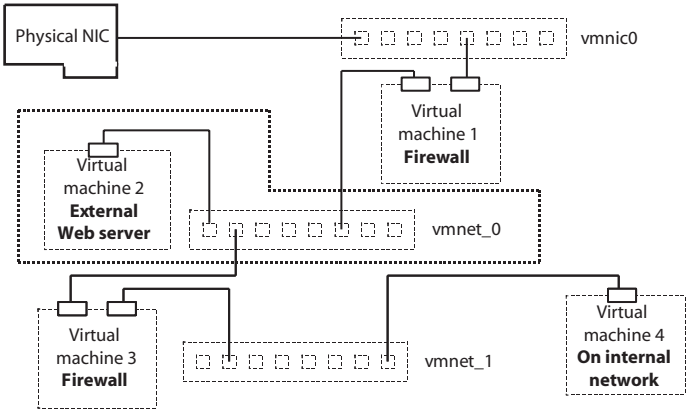
Network Virtualization

You may define up to four virtual network cards within each virtual machine. Each virtual network card has its own MAC address and may have its own IP address (or multiple addresses) as well. It may be mapped to a dedicated network interface on the physical server (which is known as a VMnic), or virtual network interfaces from multiple virtual machines may be connected to a single network card. ESX Server manages both the allocation of resources and the secure isolation of traffic meant for different virtual machines even when they are connected to the same physical network card.

A third choice involves binding a virtual network interface to a VMnet, a private network segment implemented in memory within the ESX Server system but not bound to an external network.

Private Virtual Ethernet Networks (VMnets)

VMnet connections may be used for high-speed networking between virtual machines, allowing private, cost-effective connections between virtual machines. The isolation inherent in their design makes them especially useful for supporting network topologies that normally depend on the use of additional hardware to provide security and isolation.

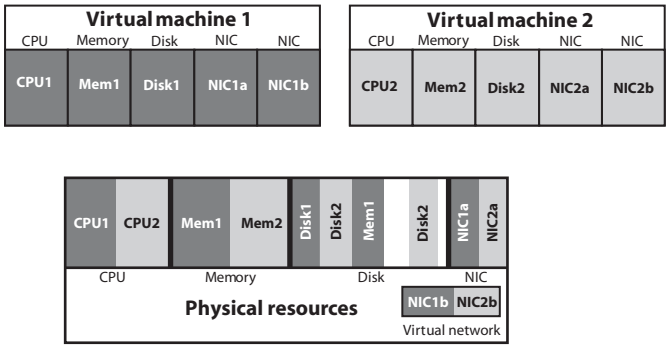


For example, an effective firewall can be constructed by configuring one virtual machine on an ESX Server system with two virtual Ethernet adapters, one bound to a VMnic (giving it a connection to a physical network) and the other bound to a VMnet. Other virtual machines would be connected only to the VMnet. By running filtering software in the dual-homed virtual machine, a user can construct an effective firewall without the need for additional hardware and with high-performance virtual networking between the virtual machines.

A similar approach can be used with multitier applications — with the Web or application servers reachable from other systems but with the database server connected only to the other tiers.

Virtualization at a Glance

ESX Server virtualizes the resources of the physical system for use by the virtual machines.



In the preceding example, each virtual machine is configured with one CPU, an allocation of memory and disk, and two virtual Ethernet adapters. In reality, they share the same physical CPU and access noncontiguous pages of memory (with part of the memory of one of the virtual machines currently swapped to disk). Their virtual disks are actually set up as files on a common file system. Each has a network interface bound to and sharing a single physical network adapter. The second network interface in each virtual machine is bound to a virtual network interface within the ESX Server system.

Software Compatibility

In the VMware ESX Server architecture, guest operating systems interact only with the standard x86-compatible virtual hardware presented by the virtualization layer. This provides the capability for VMware to support any x86-compatible operating system. In practice, however, VMware supports a subset of x86-compatible operating systems that are tested throughout the product development cycle. VMware documents the installation and operation of these guest operating systems and trains its technical personnel in their support.

Because applications interact only with their guest operating system, and not the underlying virtual hardware, once operating system compatibility with the virtual hardware is established, application compatibility is not an issue.

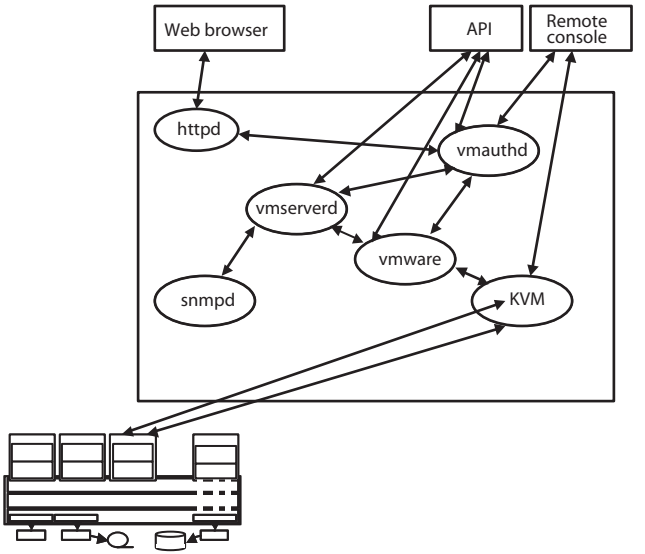
Service Console

Service Console Functions

The ESX Server system management functions and interfaces are implemented in the service console. These include the HTTP, SNMP and API interfaces described above, as well as other support functions such as authentication and low-performance device access. The service console is also installed as a first component and is used to bootstrap the ESX Server installation and configuration, as well as to boot the system and initiate execution of the virtualization layer and resource manager. In ESX Server, the service console is implemented using a modified Linux distribution.

Service Console Processes and Files

The service console provides a control API that allows the virtual machines and resource allocations to be managed. The administrator may also access these controls via pages accessed through the Web server running in the service console.



In addition to the Web server, the following processes and services involved in the management of an ESX Server system run in the service console:

- Server daemon (`vmserverd`) — Performs actions in the service console on behalf of the VMware Remote Console and the Web-based VMware Management Interface.

- Authentication daemon (`vmauthd`) — Authenticates remote users of the management interface and remote consoles using the username/password database. Any other authentication store that can be accessed using the Pluggable Authentication Module (PAM) capabilities present in the service console may also be used. This permits the use of passwords from a Windows domain controller, LDAP or RADIUS server, or similar central authentication store to be used with VMware ESX Server for remote access.
- SNMP server (`ucd-snmpd`) — Implements the SNMP data structures and traps an administrator can use to integrate an ESX Serverr system into an SNMP-based system management tool.
- In addition to these VMware-supplied services, the service console can be used to run other system wide or hardware-dependent management tools. These include hardware-specific health monitors (such as IBM Director, HP Insight Manager and others), full-system backup and disaster recovery software, and clustering and high availability products.

The server and virtual machine resources and configuration attributes that are available through the SNMP and HTTP interfaces are also visible through a file system in the service console. The files in this `/proc/vmware` name space may be examined and modified by users logged in to the service console with sufficient permissions or may be used as a point of integration for home-grown or commercial scripts and management tools.

Using VMware ESX Server

VMware ESX Server contains many features to help you manage your virtual machines' resources. In this section, we attempt to highlight some of these features, by listing tasks that you should perform on your ESX Server system.

The information contained in this table presumes that you have successfully installed and configured ESX Server on your hardware. To get help, refer to the *VMware ESX Server Installation Guide*.

Familiarizing Yourself with ESX Server

The following table includes tasks from the VMware Management Interface for an Administrator (root user), who manages and maintains ESX Server.

Task	Description
Log into the VMware Management Interface and familiarize yourself with its features.	As the root user, you have additional privileges that other users don't have. In addition to the Status Monitor page, you have access to the Options page, that allows you to configure ESX Server, including networking, security, SNMP, users and groups, storage configuration, and so on. See Modifying VMware ESX Server on page 216.
Create users and groups.	Create users and place them into groups for different access to ESX Server. For best practice, we suggest that the root user doesn't own virtual machines. In general, users who create, access, and modify virtual machines don't need to have the additional administrative privileges of the root user. You might choose to have a virtual machine owned by a "flagship user" instead of a real person. By using a "flagship user," only one user account owns the virtual machines that are in production. An advantage of using flagship accounts is that flagship users never leave the company or go on vacation. See Creating a Flagship User on page 167 and Changing Users and Groups on page 224 for more information.
Add additional disks and partitions, as needed.	When creating your VMFS volumes, you should keep the default access type public, unless you plan to use your virtual machines for clustering. If you are running clustering software, select "shared" as your VMFS volume access type. See Configuring Storage: Disk Partitions and File Systems on page 233 and Configuration for Clustering on page 329 for more information.

Task	Description
Decide how to organize your virtual machine configuration files.	The default location for these files is the home directory of the user that created the virtual machine. However, in production environments, most virtual machines belong to teams rather than to individuals. Setting up some kind of central directory structure is a good idea.
Upgrade any existing virtual machines from a previous version of ESX Server or another VMware product.	The migration procedure is heavily dependent on the version of the VMware product used to create the original virtual machine. If you are migrating a virtual machine from a previous version of ESX Server, then see Migrating Older ESX Server Virtual Machines on page 66. If you are migrating a virtual machine from VMware Workstation or VMware GSX Server, see Migrating VMware Workstation and VMware GSX Server Virtual Machines on page 67. Be sure to read these instructions carefully, before attempting to migrate your virtual machine.
Create "golden master" (template) virtual disks.	To manage ESX Server more efficiently, you can create a small number of "golden master" (template) virtual disks. for easier deployment.These are virtual disks that have complete guest operating systems, installed applications, complete management-agent installs, virus detection software, complete VMware Tools installs, and so on. You can import the disks into a VMFS volume whenever you want to create a new virtual machine. Be sure that the golden master has the tools necessary to reset system attributes (hostname and IP address, NetBIOS hostname, domain and SID [Windows operating systems] for the virtual machines you clone. Also, be sure that the user that will be running the newly created virtual machine has the appropriate user and group permissions. Use the File Manager in the VMware Management Interface to import the "golden master" virtual disks. See Using the VMware Management Interface to Manage Your Virtual Machines on page 85.

Task	Description
Set user and group permissions for the owner of a virtual machine.	Log into the management interface and click **Manage Files**. Navigate to the configuration file (`.vmx`) of the virtual machine. Click the check box next to the virtual machine's configuration file, and click **Edit Properties**. Choose read, write, and execute properties for the owner of the virtual machine, and choose read and execute privileges for the owner's group, then click **OK**. Similarly, set read and write permissions for the owner on the virtual machine's virtual disk (`.dsk`) file. (Note that read permissions for a virtual disk file are sufficient if the virtual disk is nonpersistent). See Setting Permissions for Owners of Virtual Machines on page 166 and Using Disk Modes on page 151. Be sure that the same user owns both the virtual machine's configuration and virtual disk file, and this user has full access privileges for both files.
Set user and group permissions to view a virtual machine in the Status Monitor page of the management interface.	For a user to see a virtual machine in the management interface, the user, or a group to which the user belongs, must have read access to that virtual machine. See Setting Permissions for Owners of Virtual Machines on page 166.
Set user permissions to connect to a virtual machine through the remote console.	For a user to connect to and power on a virtual machine in the remote console the user, or a group to which the user belongs, must have read and execute access to that virtual machine's configuration file. Also, the user must have execute (x) permission on all parent directories. Setting Permissions for Owners of Virtual Machines on page 166.
Configure your SNMP agent.	ESX Server ships with an SNMP agent that allows you to monitor the health of the physical machine where ESX Server is running and of virtual machines running on it. See Configuring the SNMP Agent on page 231 and Configuring the ESX Server Agent through the VMware Management Interface on page 271.

The following table includes tasks from the VMware Management Interface for a virtual machine user, who creates and modifies virtual machines.

Task	Description
Log into the VMware Management Interface and download the remote console package.	You can use the remote console to power on and power off your virtual machines, connect or disconnect devices (including the CD drive and network adapter), and set preferences (including mouse keyboard, and hot key behavior in the remote console window). You can install the remote console from the Status Monitor page of the management interface. Launch the remote console from your desktop (Windows operating systems) or from the management interface. Click the appropriate link for the operating system on your workstation.
Learn to use the management interface.	After login, the starting page of the management interface provides a summary of the virtual machines on ESX Server. Depending on your permissions, you'll be able to view and modify virtual machines. See Using the Status Monitor on page 93. Clicking on a virtual machine's name opens the details page for that virtual machine, where you can check its CPU, memory, disk, network, hardware, options, and users and events. Familiarize yourself with the information contained in these pages. See Configuring a Virtual Machine on page 106.
Create a virtual machine.	The Add Virtual Machine wizard only allows you to add a small number of devices to a virtual machine. This makes the initial creation process simpler. You may add devices later by clicking Add Device in the Hardware page for the virtual machine. If you have purchased the VMware Virtual SMP for ESX Server product, then you can create dual-virtual CPU SMP virtual machines. Be sure to take into account the type of applications you plan to run on this virtual machine when making your choices during its creation. See Creating a New Virtual Machine on page 38.
Add additional disks, drives, network adapters, and SCSI devices.	Click **Add Device** in the Hardware page for the virtual machine. See Configuring a Virtual Machine's Hardware on page 116.

Task	Description
Install guest operating system and VMware Tools.	VMware Tools is a software package installed in the guest operating system that gives you device drivers specific to VMware virtual devices where necessary, and it also includes several communication channels between the virtual machine and the ESX Server virtualization layer. See Installing a Guest Operating System and VMware Tools on page 45. For more information about VMware Tools and the services it provides, see VMware Tools Settings on page 184.

Working With ESX Server

This section includes information on maintenance tasks, performance enhancements, and general troubleshooting tips.

The following table includes ESX Server maintenance tasks for an Administrator (root user).

Back up your virtual machines.	You can do backups for each virtual machine, or from the service console. Backups from the service console are best for system images, because they result in a backup bootable virtual disk, and are suitable for rapid redeployment. See Backing Up from within a Virtual Machine on page 174.. Backups from within the virtual machine, using a backup agent, are best for application data because no system shutdown is required. See Backing Up Virtual Machines from the Service Console on page 175.
Use scripts to schedule frequent tasks.	For more information on VMware Scripting APIs, see *www.vmware.com/support/developer*.
View system logs and reports through the management interface.	As needed, view the ESX Server log files for warnings, serious system alerts and messages through the management interface. See Viewing System Logs and Reports on page 246.

The following table includes ESX Server performance-related tasks for an Administrator (root user).

Task	Description
Enhance performance on virtual machines, based on its application(s).	ESX Server applies a proportional share mechanism to CPU, memory allocation, and disk bandwidth. Typically, the more shares a virtual machine has, the more CPU, memory or disk bandwidth it has. For example, virtual machines running a CPU-intensive application should have a greater minimum CPU and memory share than a virtual machine running a non-CPU intensive application. For additional information on resource management, see VMware ESX Server Resource Management on page 381.
Enhance CPU performance on virtual machines.	You can set minimum and maximum percentages as well as memory shares for each virtual machine. You can also select the processors on which the virtual machine runs. See Configuring a Virtual Machine's CPU Usage on page 108 and CPU Resource Management on page 388.
Enhance memory utilization on virtual machines.	You can set memory shares for a virtual machine. If you have a NUMA machine, you can also select the NUMA affinity nodes for the virtual machine. See Configuring a Virtual Machine's Memory Usage on page 110, Memory Resource Management on page 403, and Using Your NUMA System on page 418.
Enhance disk bandwidth utilization on virtual machines.	You can set disk bandwidth for a virtual machine. A virtual machine with more shares has more bandwidth. See Configuring a Virtual Machine's Disk Usage on page 113 and Managing Disk Bandwidth on page 432.
Enhance networking performance on virtual machines.	You can manage networking performance by enabling traffic shaping and specifying network parameters. See Configuring a Virtual Machine's Networking Settings on page 114 and Managing Network Bandwidth on page 428.
Remove any unnecessary programs or services from your virtual machines.	Remove any unnecessary programs or services, such as CPU-intensive screensavers, from your virtual machines. Run Linux virtual machines without the X Window system, if possible.
Be sure that the service console has enough CPU and RAM.	If you are running a lot of virtual machines on ESX server, and you notice a degradation in system performance, then you should increase the CPU minimum for the service console. Configuring the Service Console on page 243.

Task	Description
Be sure there is sufficient swap space for your guest operating system.	For resource management purposes, ESX Server may increase the memory utilization within a guest operating system. Therefore, it is important to ensure that the guest operating system has sufficient swap space. Add additional swap space in the guest operating system, equal to the difference between the virtual machine's maximum and minimum memory sizes. See Admission Control Policy on page 405.
Remove any unnecessary programs or services from your service console.	Do not run the X Window system in your service console.
Use SNMP to watch memory, resource usage, and workloads on ESX Server and its virtual machines.	See Using SNMP with ESX Server on page 265.

The following table includes some general troubleshooting information.

Problem	Suggestions
Can't start a virtual machine.	Check permissions on the virtual machine configuration file and on the virtual disk. See Setting Permissions for Owners of Virtual Machines on page 166. Check that there is enough memory to power on this virtual machine. See Sizing Memory on the Server on page 424. Check that there is enough unreserved swap space. For more information, see Swap Space and Guest Operating Systems on page 408. Check that the virtual disks are in a VMFS volume. If the virtual disk file is from VMware Workstation or VMware GSX Server, be sure the virtual disk has been properly imported, through the management interface, into ESX Server. See Migrating VMware Workstation and VMware GSX Server Virtual Machines on page 67.
Can't connect to the VMware Management Interface.	Check to see if there has been a loss in IP connectivity. Check that the NIC duplex or speed matches with the Ethernet switch. Check that the service console is not swapping. Check that the root file system has available disk space.

Problem	Suggestions
Can't connect to the VMware Remote Console.	Check to see if there has been a loss in IP connectivity. Check that the NIC duplex or speed matches with the Ethernet switch. Check that the service console is not swapping. Check that the root file system has available disk space.

CHAPTER 2

Creating and Configuring Virtual Machines

The following sections describe how to create and configure virtual machines and install the VMware Remote Console:

- Creating a New Virtual Machine on page 38
- Installing a Guest Operating System and VMware Tools on page 45
- Using PXE with Virtual Machines on page 57
- Configuring a Virtual Machine to Use the LSI Logic SCSI Adapter on page 59
- Importing, Upgrading and Exporting Virtual Machines on page 64
- Preparing to Use the Remote Management Software on page 74
- Installing the Remote Console Software on page 75
- Third Party Software Compatibility on page 76
- Executing Scripts When the Virtual Machine's Power State Changes on page 77
- Configuring Virtual Machines on page 79

Creating a New Virtual Machine

You can create new virtual machines from within the VMware Management Interface. The process sets up a new configuration for each virtual machine you create this way.

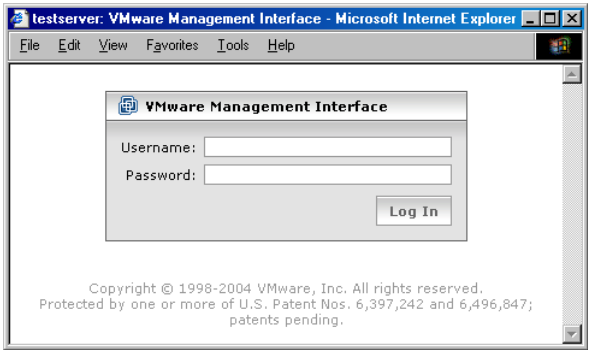
Note: You can only use ASCII characters in the entry fields when creating a virtual machine with the management interface. Thus, the virtual machine's display name and path cannot contain non-ASCII characters.

The Add Virtual Machine wizard guides you through the basic steps needed to create a virtual machine on your server. Any user who has an account on the server's service console may log in to the wizard and create a virtual machine. If you are logged in as root, you may wish to log out at this point, then log in again as a user authorized to manage the new virtual machine.

Note: Check for any VMkernel ALERT messages in the warning log files before creating a new virtual machine.

To log in to the management interface, use this URL:

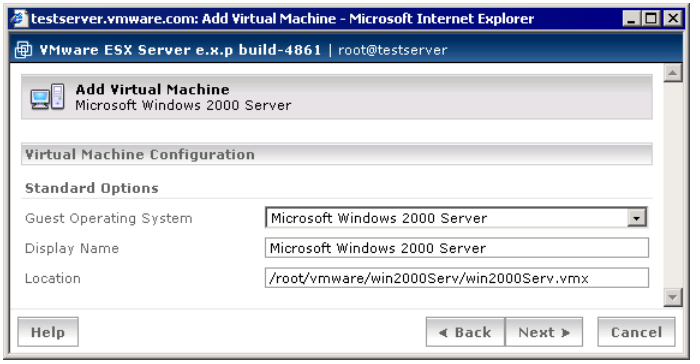
```
http://<hostname>
```


testserver: VMware Management Interface - Microsoft Internet Explorer
File Edit View Favorites Tools Help
VMware Management Interface
Username:
Password:
Log In
Copyright © 1998-2004 VMware, Inc. All rights reserved.
Protected by one or more of U.S. Patent Nos. 6,397,242 and 6,496,847;
patents pending.

1. On the management interface login page, enter your user name and password, then click **Login**.

   The Status Monitor page appears.

2. Click **Add Virtual Machine**. The Add Virtual Machine wizard starts.



3. Choose the guest operating system for your virtual machine. Corresponding default entries appear for the name of the virtual machine and the name of its configuration file. You can change these settings.

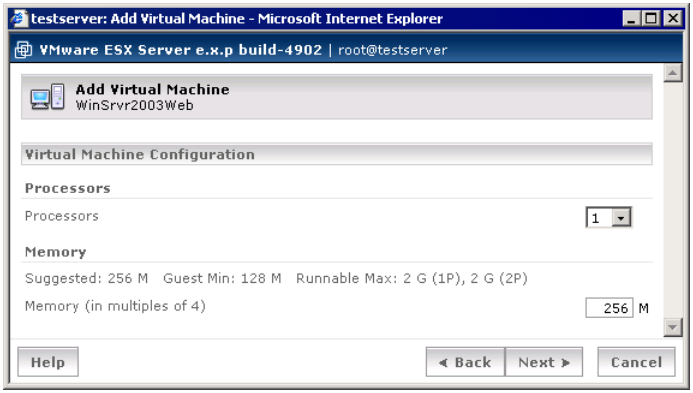
   The name you enter in the **Display Name** field is the name that is listed in the VMware Management Interface. Be sure to enter a name that allows you to distinguish this virtual machine from others you have created or plan to create.

   Be sure that the entry in the **Location** field is unique. The default path and filename are based on the guest operating system you have chosen. If other virtual machines have been created on this server, you must change the path to create a new, unique directory for the new virtual machine.

   The **Location** field contains the name of the configuration file (this file has a `.vmx` extension; this directory also contains other virtual machine files).

   Note: Configuration files for virtual machines created with VMware ESX Server 2.1 use the `.vmx` extension. Earlier versions of ESX Server used the `.cfg` extension. Virtual machine configuration files with a `.cfg` extension can be accessed by ESX Server 2.1 normally.

When you are ready to proceed, click **Next**.



4. In the **Processors** list, choose the number of virtual CPUs in your virtual machine. You may choose 1 or 2 virtual CPUs, but they must be less than or equal to the number of physical CPUs on your server.

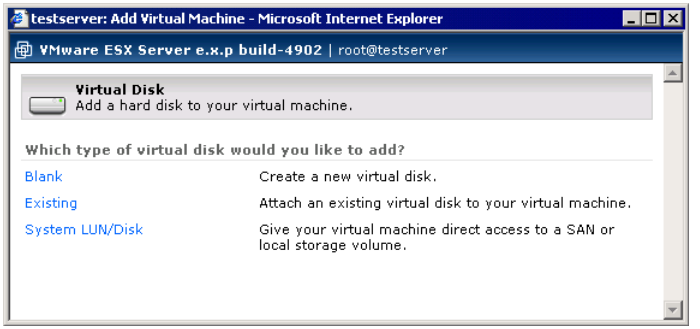
   Note: Some guest operating systems, such as Windows NT, can be configured with a single processor only. If you are configuring such a virtual machine, a note indicates this and you cannot select more than one virtual CPU.

   Note: You can create dual-virtual CPU virtual machines only if you have purchased the VMware Virtual SMP for ESX Server product. For more information on this product, contact VMware, Inc. or your authorized sales representative.

   The default setting in the **Memory** entry field depends on the guest operating system you have selected. You may need to change it to meet the demands of applications you plan to run in the virtual machine. You may change this setting later, on the virtual machine's Memory tab in the management interface. See Managing Memory Resources from the Management Interface on page 410.

   For background on allocating memory to virtual machines, see Sizing Memory on the Server on page 424.

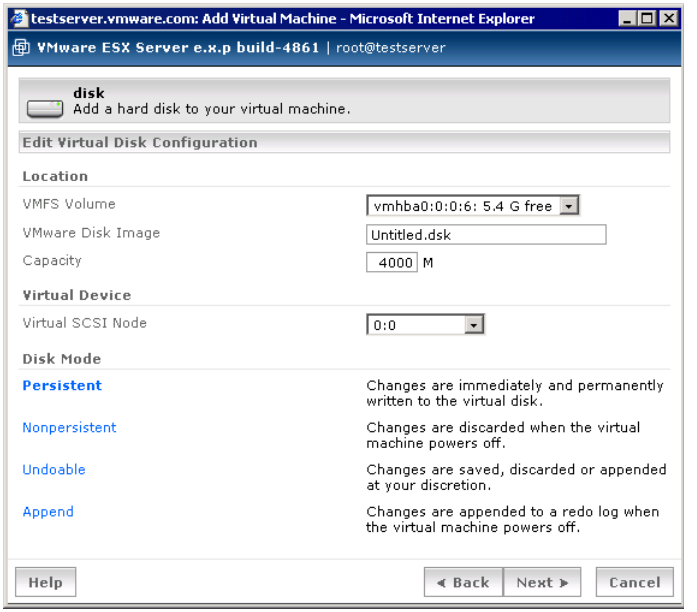
When you are ready to proceed, click **Next**.


testserver: Add Virtual Machine - Microsoft Internet Explorer
VMware ESX Server e.x.p build-4902 | root@testserver
Virtual Disk
Add a hard disk to your virtual machine.
Which type of virtual disk would you like to add?
Blank
Create a new virtual disk.
Existing
Attach an existing virtual disk to your virtual machine.
System LUN/Disk
Give your virtual machine direct access to a SAN or local storage volume.

5. Choose the type of virtual disk you want to add to the virtual machine.

   The setup process allows you to create one virtual disk for your virtual machine. You can add more virtual disks later, using the virtual machine's Hardware in the management interface. See Configuring a Virtual Machine's Virtual Disks on page 123.

   - Click **Blank** to create a new virtual disk. Then specify the following.



a. Choose the location for the new virtual disk. In the **VMFS Volume** list, choose the volume on which to locate the virtual disk. The amount of free space is listed next to the volume name, so you know how large you can make the virtual disk.

b. Give the virtual disk a name. In the **VMware Disk Image** entry field, specify the disk name, making sure the file has a `.dsk` extension.

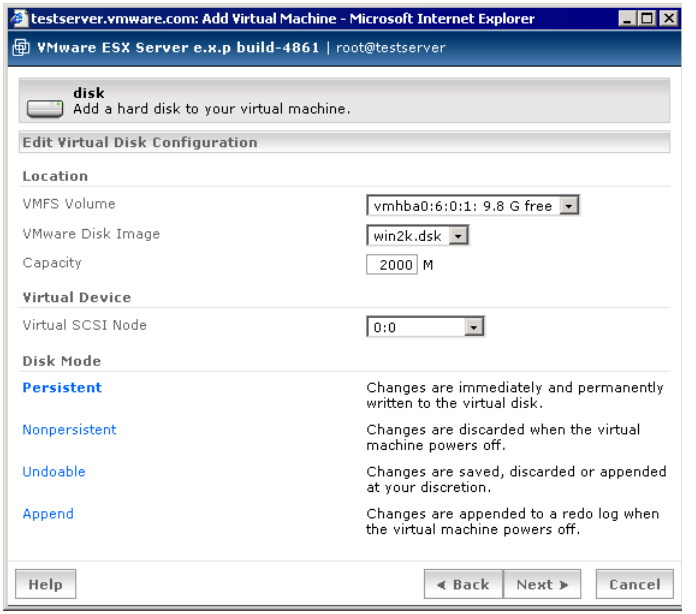
c. Specify the size of the virtual disk. In the **Capacity** entry field, specify the size of the virtual disk in MB. The default entry indicates the lesser of either 4000MB or the amount of free space available on the volume.

d. Specify the virtual device node. Select the appropriate SCSI ID in the **Virtual SCSI Node** list.

e. Choose the disk mode. Under **Disk Mode**, click **Persistent**, **Nonpersistent**, **Undoable** or **Append**. For a discussion of disk modes, see Using Disk Modes on page 151.

Note: A new virtual machine with a blank virtual disk is like a new computer with a blank hard disk. You must install a guest operating system before you can use the virtual machine. See Installing a Guest Operating System and VMware Tools on page 45.

- Click **Existing** to add an existing virtual disk to the virtual machine. Then specify the following.



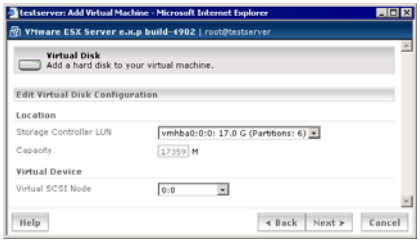
a. Choose the location of the virtual disk you want to use. In the **VMFS Volume** list, choose the volume on which the virtual disk is located.

b. In the **VMware Disk Image** list, select the virtual disk you want. The size of the virtual disk appears in the **Capacity** field; you cannot change this value.

c. Specify the virtual device node. Select the appropriate SCSI ID in the **Virtual SCSI Node** list.

d. Choose the disk mode. Under **Disk Mode**, click **Persistent**, **Nonpersistent**, **Undoable** or **Append**. For a discussion of disk modes, see Using Disk Modes on page 151.

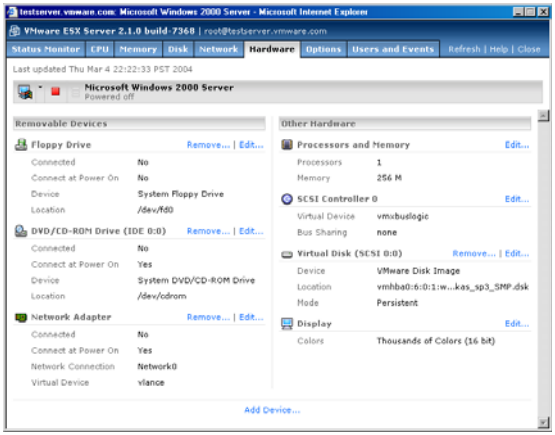
- Click **System LUN/Disk** to allow the virtual machine to access a physical disk stored on a LUN. Then specify the following.



a. Choose the LUN you want to use in the **Storage Controller LUN** list.

b. Specify the virtual device node. Select the appropriate SCSI ID in the **Virtual SCSI Node** list.

6. When you are finished configuring the virtual disk, click **Next**. The Hardware tab for this virtual machine appears.



You can change any of the default settings ESX Server assigned to the virtual machine (such as the disk mode, network card, color depth and any removable devices) or configuration items you specified as you create the virtual machine. To change any hardware, see Configuring a Virtual Machine's Hardware on page 116.

Installing a Guest Operating System and VMware Tools

This section describes the following:

- Installing a Guest Operating System in a Virtual Machine on page 45
- Installing VMware Tools in the Guest Operating System on page 46
- About the VMware Guest Operating System Service on page 51

In most cases, you configure your virtual machine with a blank (unformatted) SCSI virtual disk. You can install an operating system on this virtual disk just as you would on a new physical machine, using a standard installation CD-ROM and formatting the virtual disk at the appropriate place in the installation process.

You may also install from image files — ISO image files of installation CD-ROMs and floppy image files of any floppy disks needed for the installation. Use the VMware Management Interface to connect the virtual machine's drives to the appropriate image files before you begin the installation.

Another approach is to start with a virtual disk created with VMware Workstation 3.2 or higher or with VMware GSX Server 2.5 or higher, then configure the guest operating system to work with VMware ESX Server.

Once your guest operating system is installed, be sure to follow the directions below for installing VMware Tools and the network driver.

Installing a Guest Operating System in a Virtual Machine

To install a guest operating system and other software, work on a separate workstation and use the VMware Remote Console.

For details on installing the remote console, see Installing the Remote Console Software on page 75. Follow the directions in that section for starting a remote console on your Windows or Linux workstation and connecting to a virtual machine.

Insert the installation CD-ROM for your guest operating system in the server's CD-ROM drive. Click **Power On** on the remote console toolbar to begin setting up your guest operating system. See *www.vmware.com/support/guestnotes/doc/index.html* and the ESX Server 2.1 release notes for details on installing specific guest operating systems.

If you prefer to install over a network, you need ISO image files of installation CD-ROMs and floppy image files of any floppy disks needed for the installation. The installation instructions in this section assume you are installing from physical media.

If you are using image files, you should connect the virtual machine's CD-ROM or floppy drives to the appropriate image files before you begin installing the guest operating system.

Note: When you are installing a guest operating system on a new virtual disk, you may see a message warning you that the disk is corrupted and asking if you want to place a partition table on the disk. This does not mean there is any problem with your physical hard disk. It simply means some data needs to be written to the file that holds your virtual hard disk. All you need to do is respond **Yes**. You also need to partition and format the virtual disk as you would with a new, blank hard drive.

Installing a Guest Operating System on a Previously Formatted Raw Disk

If you try to install a guest operating system on a raw or physical disk that was formatted previously with a file system, you might see a `No operating system` error when you power on the virtual machine. This occurs because the boot order specified in the virtual machine's BIOS defaults to the floppy disk, hard disk and then the CD-ROM drive. Instead of booting from the installation CD-ROM, the virtual machine tries booting from the hard disk.

To work around this issue, do one of the following:

1. Change the boot order in BIOS so the virtual machine boots from the CD-ROM drive before trying the hard disk. When the virtual machine boots, enter the BIOS and change the boot order on the Boot menu.
2. Zero out the first 64KB of the raw disk using `dd` or a similar utility.

Installing VMware Tools in the Guest Operating System

This section describes how to install VMware Tools and the network driver in the guest operating system.

- Installing VMware Tools in a Windows Server 2003 Guest on page 47
- Installing VMware Tools in a Windows XP Guest on page 47
- Installing VMware Tools in a Windows 2000 Guest on page 48
- Installing VMware Tools and the Network Driver in a Windows NT 4.0 Guest on page 48
- Installing VMware Tools in a Linux Guest on page 49
- Installing VMware Tools in a NetWare 6.0 SP3, 6.5 or 5.1 SP6 Guest on page 50

Note the following:

- The steps for each guest operating system assume that you are working from a remote console connected to your virtual machine.

- Prepare your virtual machine to install VMware Tools. Choose **Settings** > **VMware Tools Install**.

  This option prepares the CD-ROM drive in the virtual machine to use an ISO image file containing the VMware Tools packages. This image, which appears as a regular CD-ROM disk in the virtual machine, was placed on your server machine when you installed VMware ESX Server.

Installing VMware Tools in a Windows Server 2003 Guest

1. Choose **Settings** > **VMware Tools Install**.

   This step connects the virtual machine's CD-ROM drive to an ISO image file on the ESX Server machine. If autorun is enabled in your guest operating system (the default setting for Windows operating systems), a dialog box appears after a few seconds. It asks if you want to install VMware Tools. Click **Install** to launch the installation wizard.

   If autorun is not enabled, the dialog box does not appear automatically. If it doesn't appear, run `VMwareTools.exe` from the CD-ROM drive (choose **Start** > **Run** > `D:\VMwareTools.exe`, where `D:` is the first CD-ROM drive in your virtual machine) to install VMware Tools.

2. During the installation, two Hardware Installation messages appear, stating that the VMware SVGA and VMware Pointing Device drivers have not passed Windows Logo testing. Accept these messages and continue.
3. Reboot the guest operating system when prompted.

When the installation completes, ESX Server disconnects the ISO image file and returns the virtual machine's CD-ROM drive to its original configuration.

Installing VMware Tools in a Windows XP Guest

1. Choose **Settings** > **VMware Tools Install**.

   This step connects the virtual machine's CD-ROM drive to an ISO image file on the ESX Server machine. If autorun is enabled in your guest operating system (the default setting for Windows operating systems), a dialog box appears after a few seconds. It asks if you want to install VMware Tools. Click **Install** to launch the installation wizard.

   If autorun is not enabled, the dialog box does not appear automatically. If it doesn't appear, run `VMwareTools.exe` from the CD-ROM drive (choose **Start** > **Run** > `D:\VMwareTools.exe`, where `D:` is the first CD-ROM drive in your virtual machine) to install VMware Tools.

2. During the installation, two Hardware Installation messages appear, stating that the VMware SVGA and VMware Pointing Device drivers have not passed Windows Logo testing. Accept these messages and continue.
3. Reboot the guest operating system when prompted.

When the installation completes, ESX Server disconnects the ISO image file and returns the virtual machine's CD-ROM drive to its original configuration.

Installing VMware Tools in a Windows 2000 Guest

1. Choose **Settings** > **VMware Tools Install**.

   This step connects the virtual machine's CD-ROM drive to an ISO image file on the ESX Server machine. If autorun is enabled in your guest operating system (the default setting for Windows operating systems), a dialog box appears after a few seconds. It asks if you want to install VMware Tools. Click **Install** to launch the installation wizard.

   If autorun is not enabled, the dialog box does not appear automatically. If it doesn't appear, run `VMwareTools.exe` from the CD-ROM drive (**Start > Run > `D:\VMwareTools.exe`**, where `D:` is the first CD-ROM drive in your virtual machine) to install VMware Tools.
2. When installation is complete, choose **Settings** > **Cancel Tools Install** to disconnect the ISO image file and return the virtual machine's CD-ROM drive to its original configuration.

Installing VMware Tools and the Network Driver in a Windows NT 4.0 Guest

1. Choose **Settings** > **VMware Tools Install**.

   This step connects the virtual machine's CD-ROM drive to an ISO image file on the ESX Server machine. If autorun is enabled in your guest operating system (the default setting for Windows operating systems), a dialog box appears after a few seconds. It asks if you want to install VMware Tools. Click **Install** to launch the installation wizard.

   If autorun is not enabled, the dialog box does not appear automatically. If it doesn't appear, run `VMwareTools.exe` from the CD-ROM drive (choose **Start > Run > `D:\VMwareTools.exe`**, where `D:` is the first CD-ROM drive in your virtual machine) to install VMware Tools.
2. Do one of the following:
   - If you configured this virtual machine to use the `vlance` network driver, go to step 5.

- If you configured this virtual machine to use the `vmxnet` network driver, choose **Start** > **Control Panel** > **Network** > **Adapters** and click **Add**.

3. Click **Have Disk** and enter `D:\vmnet\winnt` in the Insert Disk dialog (where `D:` is the first CD-ROM drive in your virtual machine). Click **OK** when VMware Virtual Ethernet Adapter is displayed in the Select OEM Option dialog. The VMware network driver is installed.
4. Click **Close** in the Adapters dialog box to complete the installation. Windows lets you configure the Internet address for the card.

   If you are installing on a virtual machine that was created with VMware Workstation and used networking, you must use an address different from the one the original network configuration used (since that address is still assigned to the now nonexistent virtual AMD card). Or you can change the address assigned to the AMD card at this point.

   Note: The VMware Virtual Ethernet Adapter driver runs correctly only if you have Service Pack 3 or later installed. If you do not have the proper service pack installed yet, you may get an error message such as: "System Process — Driver Entry Point Not Found; The `\SystemRoot\System32\drivers\vmxnet.sys` device driver could not locate the entry point NdisGetFirstBufferFromPacket in driver NDIS.SYS." However, even if you get this message, the driver should work if you subsequently install the correct service pack.
5. When installation is complete, and before you reboot, choose **Settings** > **Cancel Tools Install** to disconnect the ISO image file and return the virtual machine's CD-ROM drive to its original configuration.
6. Reboot the virtual machine.

Installing VMware Tools in a Linux Guest

1. Choose **Settings** > **VMware Tools Install**, then click **Install**.

   This step connects the virtual machine's CD-ROM drive to an ISO image file on the ESX Server machine.
2. In your Linux guest, become root, mount the VMware Tools virtual CD-ROM, copy the installer file from the virtual CD-ROM to `/tmp`, then unmount the CD-ROM.

   ```
   su
   mount -t iso9660 /dev/cdrom /mnt
   cp /mnt/vmware-linux-tools.tar.gz /tmp
   umount /dev/cdrom
   ```

3. Untar the VMware Tools tar file in `/tmp` and install it.

   ```
   cd /tmp
   tar zxf vmware-linux-tools.tar.gz
   cd vmware-tools-distrib
   ./vmware-install.pl
   ```

   Note: When installing VMware Tools in some versions of Linux, the installer will need to recompile VMware Tools. For this to work, you need to have a C compiler installed in the guest. In some cases you may get compiler warning messages during the VMware Tools installation. However, the control panel and drivers still work correctly.

4. Follow the remaining steps. Choose directories for the various files.
5. Choose a display size for the virtual machine. Enter the number for the choice and press Enter.
6. If you wish, start X and your graphical environment and launch the VMware Tools background application.

   ```
   vmware-toolbox &
   ```

Note: If you created this virtual machine using the `vmxnet` driver, you now need to run `netconfig` or another network configuration utility in the virtual machine to set up the virtual network adapter.

Installing VMware Tools in a NetWare 6.0 SP3, 6.5 or 5.1 SP6 Guest

1. Power on the virtual machine.
2. Prepare your virtual machine to install VMware Tools.

   Choose **File** > **Install VMware Tools**.

The remaining steps take place inside the virtual machine.

3. Load the CD-ROM driver so the CD-ROM device mounts the ISO image as a volume. Do one of the following:

   a. In the system console for a NetWare 6.5 virtual machine, type:

   ```
   LOAD CDROM
   ```

   b. In the system console for a NetWare 5.1 virtual machine, type:

   ```
   LOAD CD9660.NSS
   ```

4. When the driver finishes loading, you can begin installing VMware Tools. In the system console, type:

   ```
   vmwtools:\setup.ncf
   ```

5. When the installation finishes, the message VMware Tools for NetWare are now running appears in the Logger Screen (NetWare 6.5 guests) or the Console Screen (NetWare 5.1 guests).
6. Restart the guest operating system. In the system console, type:

   restart server

   After you install VMware Tools, make sure the VMware Tools virtual CD-ROM image (`netware.iso`) is not attached to the virtual machine. If it is, disconnect it. Right-click the CD-ROM icon in the status bar of the console window and select Disconnect.

Starting VMware Tools Automatically

You may find it helpful to configure your guest operating system so VMware Tools starts when you start X. The steps for doing so vary depending on your Linux distribution and the desktop environment you are running. Check your operating system documentation for the appropriate steps to take.

For example, in a Red Hat Linux 7.1 guest using GNOME, follow these steps.

1. Open the Startup Programs panel in the GNOME Control Center.

   Main Menu (the foot in the lower left corner of the screen) > **Programs** > **Settings** > **Session** > **Startup Programs**
2. Click **Add**.
3. In the **Startup Command** field, enter `vmware-toolbox`.
4. Click **OK**, click **OK** again, then close the GNOME Control Center.

The next time you start X, VMware Tools start automatically.

About the VMware Guest Operating System Service

When you install VMware Tools in a virtual machine, the VMware guest operating system service is one of the primary components installed. The guest service can do the following:

- Synchronize the time of the guest operating system with the time on the physical computer. See Synchronizing the Time Between the Guest and Service Consoles on page 52.
- Gracefully power off and reset a virtual machine. See Shutting Down and Restarting a Virtual Machine on page 53.

- Execute commands in the virtual machine when it is requested to halt or reboot the guest operating system. See Executing Commands When ESX Server Requests the Guest Service to Halt or Reboot a Virtual Machine on page 54.
- Pass a string from the service console to the guest operating system. See Passing a String from the Service Console to the Guest Operating System on page 54.
- Send a heartbeat to VMware ESX Server so that it knows the guest operating system is running.

The guest service starts automatically when you boot the guest operating system.

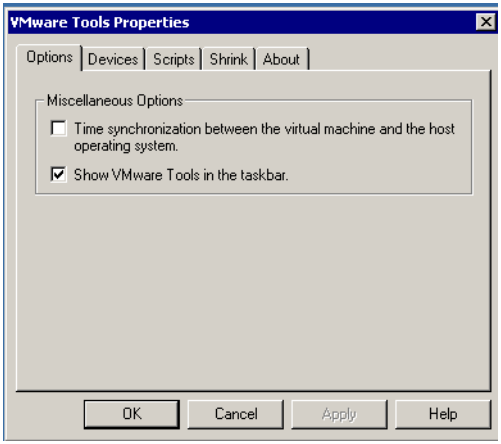
In a Linux guest, the guest service is called `vmware-guestd`. To display help about the guest service, including a list of all options, use the following command:

```
/etc/vmware/vmware-guestd --help
```

In a Windows guest, the guest service program file is called `VMwareService.exe`. To display help, right-click the VMware Tools icon in the system tray and choose **Help**.

Synchronizing the Time Between the Guest and Service Consoles

The guest service can synchronize the date and time in the guest operating system with the time in the service console once every second. In the VMware Tools control panel, on the Other tab (Options in a Linux guest), select **Time synchronization between the virtual machine and the host operating system**.



In addition, the guest service can synchronize the date and time in the guest with the service console in response to various system events — for example, when you resume from disk. You can disable this in the configuration file by setting:

```
time.synchronize.resume.disk = FALSE
```

Shutting Down and Restarting a Virtual Machine

ESX Server can signal the guest service to shut down or restart a virtual machine. After the guest service receives a request to shut down or restart, it sends an acknowledgment back to ESX Server.

You can send these requests from the VMware Management Interface or the service console's command line.

Whether it is possible to shut down or restart a virtual machine depends on the state of the virtual machine.

Shutting Down or Restarting a Virtual Machine from the VMware Management Interface

You can click ■ to shut down or to restart a virtual machine from the VMware Management Interface. After you select one of these operations, you should click to the Users and Events page for this virtual machine to respond to any messages that require a response.

Shutting down is the equivalent of using the guest operating system's shut down command, then turning off power to the virtual machine. Restarting is the equivalent of using the guest operating system's restart command.

If you receive an event log message saying, "You will need to power off or reset the virtual machine at this point," you must connect to the virtual machine with a remote console and click **Power Off** or **Reset** to complete the operation.

The power off and reset commands are not available while these operations are in progress.

You can also force power off or force reset from the menu. These commands bypass the guest service and perform the virtual equivalent of shutting off the power to a physical machine or pressing a physical reset button.

For more information, see Changing the Power State of a Virtual Machine on page 96.

Shutting Down or Restarting a Virtual Machine from the Command Line

You can shut down and restart a virtual machine from the service console command line using the `vmware-cmd` utility.

The following commands return you to the command prompt immediately, before they finish executing, although the shut down or restart process may take some time to complete:

```
vmware-cmd <vm-cfg-path> stop <powerop_mode>
vmware-cmd <vm-cfg-path> reset <powerop_mode>
```

where hard, soft or trysoft specifies the behavior of the power operation <powerop_mode>. If <powerop_mode> is not specified, the default behavior is soft. For more information, see the *VMware Scripting API User's Manual*.

Executing Commands When ESX Server Requests the Guest Service to Halt or Reboot a Virtual Machine

In a Linux guest, you can have the guest service execute specific commands when ESX Server asks it to halt or reboot the virtual machine's guest operating system. If you use nonstandard utilities or want to do additional things before shutting down or rebooting the guest operating system, you can override the default commands the guest service executes by modifying the `/etc/vmware/dualconf.vm` startup script in the guest to start the guest service with the following command line options:

```
/etc/vmware/vmware-guestd --halt-command <command>
```

where `<command>` is the command to execute when ESX Server asks the guest service to halt the guest operating system

```
/etc/vmware/vmware-guestd --reboot-command <command>
```

where `<command>` is the command to execute when ESX Server asks the guest service to reboot the guest operating system

Passing a String from the Service Console to the Guest Operating System

With ESX Server and knowledge of a scripting language like Perl or NetShell (in a Windows 2000 guest operating system), you can pass a string from your virtual machine's configuration file to the guest operating system when you use the configuration file to launch a virtual machine. This string is known as `machine.id`. The content of the string you pass to the guest operating system is up to you.

For additional details and sample scripts, including information on passing messages both ways between the service console and a guest, see the VMware Scripting API documentation at *www.vmware.com/support/developer/scripting-API/doc/Scripting_API.pdf*.

You should use this feature only if you have a good understanding of a scripting language and know how to modify system startup scripts.

Example of Passing a String from the Service Console to the Guest

If you use multiple configuration files that point to the same virtual disk, each configuration file can contain its own unique `machine.id` line.

`<config_file_1>.vmx` contains:

```
scsi0:1.present = TRUE
scsi0:1.name = "my_common_virtual_hard_drive.dsk"
```

```
scsi0:1.mode = "persistent"
machine.id = "the_id_for_my_first_vm"
```

`<config_file_2>.vmx` contains:

```
scsi0:1.present = TRUE
scsi0:1.name = "my_common_virtual_hard_drive.dsk"
scsi0:1.mode = "persistent"
machine.id = "the_id_for_my_second_vm"
```

Using `machine.id`, you may pass such strings as the Windows system ID (SID), a machine name or an IP address. In the guest operating system startup script, you may then have the guest service retrieve this string, which can then be used by your script to set your virtual machine's system ID, machine name or IP address.

In the following example, we use a Linux guest to illustrate how you can use the guest service to retrieve a string containing what becomes the virtual machine's machine name and IP address. We use RedHat62VM as the machine name and 148.30.16.24 as the IP address.

1. Define the `machine.id` string. Define the following option in your virtual machine's configuration file (as described in Modifying the Configuration File Directly (Advanced Users Only) on page 141):
   ```
   machine.id = "RedHat62VM 148.30.16.24"
   ```
   Then launch a virtual machine using this configuration file.
2. Retrieve the `machine.id` string in the virtual machine. In your system startup script, before the network startup section, add the following command:
   ```
   /etc/vmware/vmware-guestd --cmd 'machine.id.get'
   ```
   Note: in a Windows guest, the command to retrieve the string is
   ```
   VMwareService --cmd machine.id.get
   ```
   You need to further customize this startup script so it uses the string the guest service retrieved during startup to set the virtual machine's network name to RedHat62VM and its IP address to 148.30.16.24. This should be located in the script before the network services are started. If you're using a Windows 2000 guest operating system, for example, you can call the NetShell utility (`netsh`) and pass it the contents of the string, which it can then use appropriately (that is, it can set a new IP address for the virtual machine, if that is what was passed in the string originally).

From the service console, you can prevent the service console from passing a string to the guest operating system via the guest service. To do this, set the following line in your virtual machine's configuration file.

```
isolation.tools.machine.id.get.disable = TRUE
```

Using PXE with Virtual Machines

You can use a preboot execution environment (commonly known as PXE) to boot a virtual machine over a network. When you use PXE with a virtual machine, you can:

- Remotely install a guest operating system over a network without the need for the operating system installation media.
- Deploy an image of a virtual disk to the virtual machine.
- Boot a Linux virtual machine over the network and run it diskless.

You use PXE with your virtual machine in conjunction with remote installation tools such as Windows 2000 Remote Installation Services or the Red Hat Linux 9.0 installer's PXE package. You can use Ghost or Altiris to stream an image of an already configured virtual disk to a new virtual machine.

Make sure the virtual machine has a virtual network adapter; one is installed by default. ESX Server supports PXE when the virtual machine is configured to use either the `vmxnet` or `vlance` virtual network adapter.

The virtual machine must have a virtual disk without a guest operating system installed.

When a virtual machine boots and there is no guest operating system installed, it proceeds to boot from devices (hard disk, CD-ROM drive, floppy drive, network adapter) in the order in which they occur in the boot sequence specified in the virtual machine's BIOS. If you plan to use PXE with a virtual machine, it is a good idea to put the network adapter at the top of the boot order. When the virtual machine first boots, press `F2` to enter the virtual machine's BIOS and change the boot order there.

As the virtual machine boots from the network adapter, it tries to connect to a DHCP server. The DHCP server provides the virtual machine with an IP address and a list of any PXE servers available on the network. After the virtual machine connects to a PXE server, it can connect to a bootable disk image (such as an operating system image or a Ghost or Altiris disk image) and start installing a guest operating system.

VMware has tested and supports the following PXE configurations with ESX Server:

- Remote installation of a Windows Server 2003 guest operating system from a server running Windows Server 2003 Automated Deployment Services
- Remote installation of a Windows 2000 guest operating system from a server running Windows 2000 Server/Advanced Server Remote Installation Services
- Remote installation of a Linux guest operating system from a Red Hat Enterprise Linux 3.0 AS PXE boot server

- Remote installation of a supported guest operating system from a Ghost image using Windows 2000 and Ghost RIS Boot package
- Remote installation of a supported guest operating system from an Altiris image using a Windows 2000 Altiris server
- Network booting a Linux virtual machine by connecting with the Linux Diskless option to a Red Hat Enterprise Linux 3.0 AS server

Note: ESX Server does not support installation of a Windows XP guest operating system using PXE.

Configuring a Virtual Machine to Use the LSI Logic SCSI Adapter

ESX Server virtual machines can use virtual BusLogic and virtual LSI Logic SCSI adapters. By default, virtual machines use the BusLogic adapter. However, new Windows Server 2003 virtual machines are configured to use the LSI Logic adapter by default.

You can add the LSI Logic SCSI adapter to any virtual machine by modifying its configuration file. For an existing virtual machine or for a new Windows XP or Windows 2000 virtual machine, further steps are needed in the guest operating system.

Windows XP and Windows 2000 do not include a driver for the LSI Logic SCSI adapter, so these guests use the BusLogic adapter by default. However, to use the LSI Logic SCSI adapter with a Windows XP or Windows 2000 virtual machine, you must download the driver from the Download Center at the LSI Logic Web site. Go to *www.lsilogic.com/support/* and look for the LSI20320 SCSI adapter driver for your guest operating system. The files are in a WinZip archive.

Note: Linux distributions with kernels in the 2.4.18 series or later include a driver that supports the LSI Logic adapter. If your guest has an older kernel and you want to use the LSI adapter instead of the BusLogic adapter, VMware recommends you upgrade the kernel packages to the latest version available for the distribution. You do not need to download the driver from LSI Logic.

Adding the Adapter to the Virtual Machine's Configuration File

For both Windows and Linux virtual machines, you need to modify the virtual machine's configuration file to use the LSI Logic SCSI adapter. For a new virtual machine, complete the following steps before you install the guest operating system.

For an existing virtual machine with which you want to use the LSI Logic adapter, shut down the guest operating system and power off the virtual machine before following these steps.

Caution: Even though SuSE Linux 8.1 includes the correct driver for LSI Logic, due to an error in a SuSE Linux process, the guest operating system must first be installed with the BusLogic driver. Once the SuSE Linux 8.1 guest operating system has been installed and boots, shut down the virtual machine and complete the steps below.

1. Connect to the service console and, using a text editor there, open the virtual machine's configuration file (`.vmx`).

2. Do one of the following:
   - If you are adding the LSI Logic adapter to a new virtual machine that is configured for a BusLogic adapter (which has a guest operating system other than Windows Server 2003), switch the original BusLogic adapter to the LSI Logic adapter by changing this line:
     `scsi<n>.virtualDev = "vmxbuslogic"`
     to
     `scsi<n>.virtualDev = "vmxlsilogic"`
   - If you are adding the LSI Logic adapter to an existing virtual machine that is configured for a BusLogic adapter, add the LSI Logic adapter with no devices after the BusLogic device. For example, if you have one SCSI adapter in the virtual machine already, the configuration file looks something like this:

```
###
### SCSI devices
###

# SCSI controller scsi0

scsi0.present = "TRUE"
scsi0.virtualDev = "vmxbuslogic"

scsi0:1.present = "TRUE"
scsi0:1.name = "vmhba0:6:0:1:win2k.dsk"
scsi0:1.mode = "persistent"
```

     To add the LSI Logic adapter, type the following lines after the BusLogic device information:

```
scsi1.present = "TRUE"
scsi1.virtualDev = "vmxlsilogic"
```

3. Save your changes, then close the configuration file.

With the LSI Logic SCSI adapter added to the virtual machine's configuration, now it must be recognized by the guest operating system. Windows and Linux guest operating systems differ in how you can proceed. Follow the appropriate steps below.

For new Linux virtual machines (using the appropriate kernel), you can now install the guest operating system, which will be configured for using the LSI Logic adapter automatically. No other steps are necessary. For an existing Linux virtual machine, complete the steps under Configuring the LSI Logic SCSI Adapter in a Linux Guest Operating System on page 62.

Configuring the LSI Logic SCSI Adapter in a Windows Guest Operating System

Before you begin configuring your Windows guest, download the LSI Logic driver from the LSI Logic Web site, as mentioned above.

For a new virtual machine, unzip the driver files to a floppy disk. This floppy disk is needed while installing the guest operating system.

For an existing virtual machine, unzip the driver files into a directory in the guest operating system, then shut down the guest and power off the virtual machine.

1. Power on the virtual machine.
2. Do one of the following:
   - If you are installing a new guest operating system, press F6 at the beginning of the installation to have Windows prompt for a driver disk. When you are asked to load additional drivers, insert the floppy disk containing the driver files and let Windows copy the driver files and continue the installation. Do not remove the floppy disk from the floppy drive until the installer reboots the guest.
   - If you are changing from the BusLogic to the LSI Logic adapter in an existing virtual machine, the guest operating system recognizes the presence of the LSI Logic adapter and the Add New Hardware wizard starts after you log in. Browse to the directory where you unzipped the driver files and let Windows copy them to the correct place.
3. After you install the LSI Logic driver, make sure the virtual machine boots completely. Check the guest operating system's Device Manager to ensure the LSI Logic adapter appears and is working.

   If you are installing the LSI adapter in a new guest operating system, you are finished. If you are switching from a BusLogic adapter in an existing virtual machine, continue with the remaining steps.
4. Shut down and power off the virtual machine, then edit the configuration file. Switch the original BusLogic adapter to the LSI Logic adapter by changing this line:
   ```
   scsi0.virtualDev = "vmxbuslogic"
   ```
   to
   ```
   scsi0.virtualDev = "vmxlsilogic"
   ```

5. Remove the LSI Logic adapter you added previously by removing these lines:
   ```
   scsi1.present = "TRUE"
   scsi1.virtualDev = "vmxlsilogic"
   ```
6. Save your changes to the configuration file and boot the virtual machine again. After the virtual machine boots, verify in the Device Manager that the guest is using the LSI Logic driver only.

   Note: Since the driver has been installed, the guest should find it automatically. Sometimes moving the virtual devices around causes the PCI slots to change, so the guest might detect some devices (like the `vmxnet` network driver) again. Let the operating system detect the devices and continue.

Configuring the LSI Logic SCSI Adapter in a Linux Guest Operating System

The following steps apply to existing virtual machines running Red Hat Linux 7.3 and to SuSE Linux 8.0 guest operating systems and later distributions. The kernels that come with these and later distributions include a driver that supports the LSI Logic SCSI adapter. The driver is called `mptscsih` and depends on another module called `mptbase`. Earlier kernels may have the `mptscsih` driver, but they do not support this adapter.

Note: For a new Linux virtual machine in which you intend to install a Red Hat Linux 7.3 or SuSE Linux 8.0 guest operating system or a later distribution, you only need to install the guest operating system. The guest is configured to use the LSI Logic adapter during installation.

To use the LSI Logic adapter in an older distribution, upgrade the virtual machine's kernel or patch the kernel with the source from the LSI Logic Web site and re-compile the kernel. Verify that the LSI Logic adapter is detected. At a command prompt in the guest, type:

```
modprobe mptscsih
```

If there are no errors, verify with `lsmod` that `mptscsih` and `mptbase` are both installed, then continue. Otherwise you must determine why the driver did not load.

For an existing Linux virtual machine with the modified configuration, the guest needs to boot with the LSI Logic SCSI adapter, so it tries to load that driver from the initial RAM disk (`initrd`) before the root partition is mounted. Try the following:

1. Edit `/etc/modules.conf` and set `scsi_hostadapter` to `mptscsih`.

2. Create a new initial RAM disk for the running kernel.
   `mkinitrd --preload mptbase`
   `/boot/initrd-<kernelname>-lsi.img <kernelname>`

   Where `<kernelname>` is the version of the guest's kernel; such as 2.4.18-3.

   The `modules.conf` modification you made in the previous step allows `mkinitrd` to provide the LSI Logic SCSI driver to the kernel when booting.

3. Edit `/etc/lilo.conf` or `/boot/grub/grub.conf` (depending on which is in use in the guest). Create a new entry that uses the existing kernel, but the new RAM disk file. Make sure you keep the original boot entry, in case you have a problem and need to boot with the BusLogic adapter. Install the boot loader (`lilo`, or `grub-install /dev/sda`) again.

4. Shut down and power off the virtual machine, then edit the configuration file in the management interface. Switch the original BusLogic adapter to the LSI Logic adapter by changing this line:
   `scsi0.virtualDev = "vmxbuslogic"`
   to
   `scsi0.virtualDev = "vmxlsilogic"`

5. Remove the LSI Logic adapter you added previously by removing these lines:
   `scsi1.present = "TRUE"`
   `scsi1.virtualDev = "vmxlsilogic"`

6. Save your changes to the configuration file and boot the virtual machine again. The virtual machine should boot. If it does not boot, switch the configuration back to BusLogic and boot with the original configuration, and troubleshoot the following issues:

   - The RAM disk may not have been created correctly; it must preload `mptbase` and load `mptscsih` as the main SCSI driver, which you specified in step 1. Verify that both of these activities occurred.
   - The boot loader may not have been installed or was not installed correctly, which results in the loader loading the old ram disk image. Check the boot loader configuration and install the boot loader again.
   - The kernel does not support the LSI Logic adapter. Check that you can manually `modprobe mptscsi` without errors, and that it appears in the output of `lsmod`. If not, upgrade the kernel and start over again.

   Note: You may see different results on different distributions.

Importing, Upgrading and Exporting Virtual Machines

Importing, upgrading and exporting virtual machines involves the following activities:

- Configuring a Virtual Machine to Use More than One Virtual Processor
- Migrating Older ESX Server Virtual Machines on page 66
- Migrating VMware Workstation and VMware GSX Server Virtual Machines on page 67
- Importing a GSX Server or Workstation Virtual Machine on page 70
- Exporting Virtual Machines on page 72

Configuring a Virtual Machine to Use More than One Virtual Processor

When you create a virtual machine with ESX Server 2.1, you can choose to create it with one or two virtual processors. In order to configure a virtual machine with more than one virtual processor, you must meet the following conditions:

- The virtual machine must be created under ESX Server 2.1. VMware does not support upgrading a virtual machine created under ESX Server 1.5.2 to ESX Server 2.1 and configuring it as a multiprocessor or ACPI virtual machine. Nor can you create a virtual machine under VMware GSX Server 2.5.1 or VMware Workstation 4.0, import it to ESX Server 2.1 and upgrade the number of virtual processors.
- You must have purchased the VMware Virtual SMP for ESX Server product and you must have created the virtual machine under ESX Server 2.1. For more information on the VMware Virtual SMP for ESX Server product, contact VMware or your authorized sales representative. Once you have the license, you install the product by entering the serial number when you configure the ESX Server system. See the *VMware ESX Server Installation Guide*.
- The guest operating system must support multiprocessor systems. Examples include Windows Server 2003, Windows 2000 and Red Hat Enterprise Linux AS 2.1. Review the list of supported guest operating systems in the *VMware ESX Server Installation Guide* to see which guests are multiprocessor- or SMP-capable.
- The virtual machine cannot have more virtual processors than the ESX Server system has physical processors. Thus, to create a virtual machine with two virtual processors, the ESX Server system must have at least two physical processors.

First you must configure the virtual machine to use more than one virtual processor. Use the management interface. For instructions, see Configuring a Virtual Machine's Memory and Virtual Processors on page 120. Then follow the steps appropriate to the guest operating system below.

Windows Server 2003 Guest Operating Systems

Windows Server 2003 upgrades the HAL automatically. All you need to do is use the management interface to configure the virtual machine to use more than one virtual processor. When you power on the virtual machine, the guest operating system detects the new processor and updates the HAL accordingly.

Windows 2000 Guest Operating Systems

For Windows 2000 guest operating systems, to use more than one virtual processor, you need to configure the virtual machine to use more than one virtual processor. Then you need to upgrade the guest operating system's HAL. Virtual machines created with one processor in ESX Server 2.1 use the ACPI Uniprocessor HAL. To be able to use two virtual processors, you need to use the ACPI Multiprocessor HAL. To change the HAL, you should follow the instructions in Microsoft's Knowledge Base. Go to *support.microsoft.com/default.aspx?scid=kb;EN-US;237556*.

Linux Guest Operating Systems

In order to create a virtual machine with more than one virtual processor, you must create a new virtual machine with two virtual processors then install the guest operating system in this new virtual machine.

The Linux distribution must support SMP. Supported Linux guest operating systems that can be configured with more than one virtual processor include Red Hat Enterprise Linux 2.1, Red Hat Linux 9.0, SuSE Linux 8.2 and SuSE Linux Enterprise Server (SLES) 8.

Downgrading to One Virtual Processor

VMware ESX Server does not support downgrading a multiprocessor virtual machine to a uniprocessor virtual machine.

Migrating Older ESX Server Virtual Machines

You can use virtual machines created with versions of ESX Server older than 2.1. Virtual machines created in ESX Server 1.5 can work as is; however, to take advantage of the new features of ESX Server 2.0, there are steps you need to take to upgrade your virtual machines.

If you created the virtual machine under ESX Server 1.5 and do not want to upgrade the virtual machine, you can run it in legacy mode. See Running ESX Server 1.5 Virtual Machines in Legacy Mode below.

Note: Virtual machines created under ESX Server 1.0 or ESX Server 1.1 must be upgraded to ESX Server 1.5 before they can be migrated to ESX Server 2.1. Once these virtual machines run under ESX Server 1.5, you can migrate them to ESX Server 2.1. See the upgrade instructions at *www.vmware.com/support/esx15/doc/install_esx.html*.

First, you need to upgrade the virtual machine's hardware. This must be done for any virtual machine created under ESX Server 1.0, 1.1 or 1.5. To upgrade the virtual machine's hardware, make sure the virtual machine is powered off. On the Status Monitor page in the management interface, click the arrow to the right of the terminal icon ( ) and choose **Configure Hardware**. On the Hardware tab, click **Upgrade Virtual Hardware**, then click **OK** to upgrade the hardware.

Then, assign disk bandwidth shares to the virtual machine. For more information, see See Managing Disk Bandwidth from the Management Interface on page 433.

Upgrading Windows Server 2003 Guest Operating Systems Created by ESX Server 1.5.2

If you used ESX Server 1.5.2 to create a virtual machine with a Windows Server 2003 guest operating system, then you must update the `guestOS` configuration parameter in the virtual machine's configuration file. Otherwise, this virtual machine will not run properly with ESX Server 2.1.

Complete the following steps to update the `guestOS` configuration parameter:

1. Log into the VMware Management Interface as the owner of the virtual machine, or as the root user.
2. Click the arrow to the right of the terminal icon for the Windows Server 2003 virtual machine and choose **Configure Options.**
3. Click the **Options** tab, then under **Verbose Options**, click the link.
4. Change the value of the `guestOS` configuration parameter to one of the following:
   - winNetWeb (Windows Server 2003 Web Edition)

- winNetStandard (Windows Server 2003 Standard Edition)
- winNetEnterprise (Windows Server 2003 Enterprise Edition)

5. Click **OK** to save your changes.

Running ESX Server 1.5 Virtual Machines in Legacy Mode

You can choose to not upgrade an ESX Server 1.5 virtual machine and run it in legacy mode. This allows you to use the virtual disk as is. Changes can be written to the virtual disk file. You can add any virtual hardware to a legacy virtual machine, including upgrading VMware Tools. However, any virtual machines created before ESX Server 2.1 can only have a single virtual processor. Multiprocessor virtual machines must be created under ESX Server 2.0.

Using the LSILogic SCSI Adapter

Prior to ESX Server 2.1, virtual machines only used BusLogic SCSI adapters. Now you can choose to use either the BusLogic SCSI adapter or the LSI Logic SCSI adapter for your virtual machines.

If you are upgrading an older ESX Server virtual machine, you should make sure you upgraded the virtual machine hardware before proceeding. Install the latest version of VMware Tools. If necessary, power off the virtual machine and upgrade the virtual hardware. Make sure the guest operating system boots completely. Power off the virtual machine and back it up. Now you are ready to add the LSI Logic adapter.

To add the LSI Logic SCSI adapter to the virtual machine, see Configuring a Virtual Machine to Use the LSI Logic SCSI Adapter on page 59.

Migrating VMware Workstation and VMware GSX Server Virtual Machines

You can migrate virtual machines created with VMware Workstation 4 or earlier or VMware GSX Server 2.5.1 or earlier to your VMware ESX Server system.

The virtual machine you want to migrate must have been configured with a virtual SCSI disk and have a supported guest operating system installed. For the list of supported guest operating systems, see the *VMware ESX Server Installation Guide*.

Note: Virtual machines created under versions earlier than GSX Server 2.0 or Workstation 3.2 must be upgraded to ESX Server 1.5 before they can be migrated to ESX Server 2.1. Once these virtual machines run under ESX Server 1.5, you can migrate them to ESX Server 2.1. See the upgrade instructions at *www.vmware.com/support/esx15/doc/install_esx.html*.

First you need to import the virtual disks and any redo logs to the server and create a new virtual machine configuration. See Importing a GSX Server or Workstation Virtual Machine on page 70.

On the VMFS partition where you store your virtual machines, make sure you have enough space to hold the full capacity of the source virtual disk. A virtual disk created in ESX Server has its full capacity allocated at the time the virtual disk file is created; for a 2GB virtual disk, the virtual disk file is 2GB in size at the time the disk is created.

In VMware Workstation and GSX Server, the virtual disk file usually starts smaller and grows to the maximum capacity as data is added. Thus, you can create a 2GB virtual disk, install the guest operating system and the virtual disk may be contained in a 500MB file. However, when you migrate the virtual disk to ESX Server, the import process converts the disk for ESX Server and the disk occupies 2GB of space on the partition.

Caution: If you created a virtual disk that is contained in a single `.vmdk` file larger than 2GB (the default for Workstation 4 virtual disks) and want to migrate the virtual disk to ESX Server, you must FTP or copy the disk from the Workstation host to the ESX Server machine. Once the file has been copied to the service console, you must use `vmkfstools` to import the disk into ESX Server. For the syntax on how to import the disk, see Examples Using vmkfstools on page 238.

If the virtual disk has a redo log (GSX Server 2.5 or Workstation 3.2 or earlier virtual machines) or a snapshot (Workstation 4 virtual machines) associated with it, you can choose to do either of the following:

- If you want the most current representation of the virtual disk before you import it, commit the changes in the redo log or take a snapshot just before importing.
- If you want to use the base disk, discard the changes in the redo log or migrate the virtual machine without the snapshot (`.vmss`) file.

When you install VMware Tools in the VMware ESX Server virtual machine, you may set up a new network driver.

Virtual machines migrated from Workstation and GSX Server cannot be configured to use more than one virtual processor.

Disk Geometry Failures When Importing GSX Server Virtual Machines

If you used `vmkfstools` to import a virtual machine created under GSX Server to ESX Server, after you import the virtual machine, you may see the following message:

"Disk geometry mismatch. To power on the virtual machine you should specify `scsi<adapter-id>:<target-id>.biosGeometry="<cylinders>/<heads>/<sectors>"` in the configuration file."

A similar problem may occur if you used the management interface file manager to import the virtual machine, though no message appears. If you have problems powering on a virtual machine with the imported disk, then you may have a mismatch with the virtual disk's geometry.

Virtual disks created under GSX Server use a different disk geometry than virtual disks created under ESX Server. To determine the correct disk geometry, run the following `vmkfstools` command on the source virtual disk (the copy of the virtual disk on the GSX Server host, not the disk in a VMFS partition):

```
vmkfstools -g //path/to/<sourceVirtualDisk>.vmdk
```

Once you determine the disk geometry, you can add the correct geometry information to the configuration file. To modify the configuration file, follow the steps under Modifying the Configuration File Directly (Advanced Users Only) on page 141.

Create an option called `scsi<adapter-id>:<target-id>.biosGeometry` and set the value of the option to `"<cylinders>/<heads>/<sectors>"`, where `<adapter-id>:<target-id>` is the SCSI ID of the virtual disk on the ESX Server system and `"<cylinders>/<heads>/<sectors>"` is the number of cylinders, heads and sectors on the virtual disk returned by the `vmkfstools` command.

For example, if the virtual disk is located on the SCSI 0:0 node in the virtual machine on the ESX Server system, and you determine that the disk geometry of the original virtual disk (the one on the GSX Server host) contains 261 cylinders, 255 heads and 63 sectors, you would add the following option to the configuration file:

```
scsi0:0.biosGeometry
```

And you would assign the following value to the new option:

```
261/255/63
```

Otherwise, if you do not add the new geometry information to the configuration file, when you power on the virtual machine, a message appears stating `Error loading operating system`. To power on the virtual machine, you must add the new option to the configuration file, as discussed above.

Path Name Failures When Importing GSX Server Virtual Machines

Plain disks used with virtual machines created in GSX Server may contain disk file names that ESX Server cannot translate. Versions 2.5 and earlier of GSX Server used absolute path names to identify disk files when creating plain disks. Not all plain disks created with earlier versions of GSX Server contain path names preventing ESX Server from importing them. If you attempt to import a plain disk with `vmkfstools` and ESX Server displays:

```
DiskLib_Open() failed. No such file or directory (131591)
```

you should check the path name in the plain disk.

Note: This problem applies only to plain disks. Virtual and raw disks created in GSX Server should import correctly using `vmkfstools`.

Open the plain disk descriptor (`.pln`) file and locate the path name to the disk file. If the path name refers outside the directory containing the descriptor file, you must change it. For example, if the path name is:

```
C:\user\vmware\VMs\W2KServSP3\Win2KSv1.dat
```

ESX Server cannot translate the GSX Server path name to locate the plain disk data (`.dat`) file.

You can repair the plain disk by locating the data file in the same directory as the descriptor file and changing the path name to refer to the data file directly. In this example, edit the descriptor file to remove the absolute path from the file name:

```
Win2KSv1.dat
```

and save the file. Now if you import the plain file:

```
$ vmkfstools -i Win2KSv1.pln vmhba0:0:2:Win2KSv1.dsk
```

the command locates `Win2KSv1.dat` in the same directory and imports it into the specified ESX Server virtual disk file.

Importing a GSX Server or Workstation Virtual Machine

Follow these steps to import a virtual machine to VMware ESX Server.

1. Be sure you have access to the files in the directory that holds the source virtual machine. You may be able to mount the source location, or you may prefer to FTP or copy the files to a temporary folder on the service console.

   If you are not sure where the source files are, open the virtual machine in the VMware product you used to create it, open the Configuration Editor (**Settings** > **Configuration Editor**). On a Windows host, click the name of the drive you want to migrate. In the Disk file section, click **Choose** to see the location information.

On a Linux host, expand the SCSI Drives tree and click the name of the drive you want to migrate. Click **Choose** to see the location information.

2. Using a Web browser, log in to the ESX Server machine as root and click **Manage Files**. Use the file manager in the VMware Management Interface to perform all the file copy steps described below. For information on using the file manager, see Using the VMware Management Interface File Manager on page 163.
3. In the file manager, navigate to the location of the source disk files. Select the main disk (`.vmdk` or `.dsk`) file for the virtual disk you are migrating, then click **Copy**.

   Caution: Do not cut the virtual disk file. This ensures you have a backup copy of the virtual disk.
4. Navigate to the **vmfs** folder and open the folder for the VMFS partition where you want to store the virtual disk file. Click **Paste**.

   A dialog box appears with the message "You are transferring one or more console virtual disks to a VMFS partition. In order for virtual machines to access these disks, they must be converted to the VMFS format. Although you can convert console disks at any time, it is recommended that you do so now."

   This means the VMFS partition recognizes the files as a virtual disk and converts the disk to the VMFS-2 format during the import. This allows the disk to be accessed by virtual machines running under ESX Server 2.1.

   The file you are pasting is selected. Click **OK**.

   The virtual disk is imported to the VMFS partition and converted to the new format.

   Note: If you do not see the message about transferring disks, there is a problem with the import. Be sure you are pasting to the correct **vmfs** folder.
5. Select the newly imported `.dsk` file, then click **Edit Properties**.
6. Change the user and group names in the right-hand column so the file's owner and group match those of the user who will run the virtual machine.

   Click **OK**.
7. Log out, then log back in as the user who will run the new virtual machine.
8. Create a new virtual machine as described in Creating a New Virtual Machine on page 38. When you set the file name for the new virtual machine's disk, be sure to use the virtual disk file you just copied to the VMFS partition.

9. If you imported the virtual machine from ESX Server 1.5.2, GSX Server 2.5.1 or Workstation 3.2 or earlier, upgrade the virtual hardware.

   Make sure the virtual machine is powered off. On the Status Monitor page, click the arrow to the right of the terminal icon ( ) and choose **Configure Hardware**. On the Hardware tab, click **Upgrade Virtual Hardware**, then click **OK** to upgrade the hardware.

10. If you imported a Windows Server 2003 or Windows XP virtual disk from Workstation 4.0 or GSX Server 2.5, you need to modify one entry in the virtual machine's configuration file before you power on the virtual machine.

    To modify the configuration file, follow the steps at Modifying the Configuration File Directly (Advanced Users Only) on page 141. In the configuration file, look for the option `scsi0.virtualDev` and change the value from `vmxlsilogic` to `vmxbuslogic`.

11. Boot your virtual machine in a remote console and install VMware Tools and the network driver in the virtual machine. For more information, see Installing VMware Tools in the Guest Operating System on page 46.

    Some guest operating systems display messages about detecting hardware changes and require you to reboot the virtual machine. This occurs because VMware ESX Server uses an emulation for chipsets and BIOS that is slightly different from those used by other VMware products.

Exporting Virtual Machines

You can export a virtual machine to Workstation 4, provided it is a uniprocessor virtual machine; multiprocessor (SMP) virtual machines cannot be exported to Workstation 4. If the virtual disks are in undoable mode, you must commit the changes in the redo log before exporting the virtual machine in order for your changes to carry over.

However, Workstation 4 does not support the LSILogic SCSI adapter. To use the SCSI adapter in the virtual machine, you must switch back to the BusLogic adapter.

ESX Server 2.1 does not support exporting virtual machines to ESX Server 1.5 or earlier, VMware Workstation 3.2 earlier or VMware GSX Server 2.5 or earlier.

You should uninstall VMware Tools from a virtual machine before exporting it for use in Workstation or GSX Server.

Use the `vmktools` command in the Service Console to export virtual disks associated with a virtual machine. For details, see the section on using the `-exportfile` option of `vmkfstools` in Basic vmkfstools Options on page 297.

You can find an example of how to use the `-exportfile` option in Examples Using vmkfstools on page 305.

Preparing to Use the Remote Management Software

You can manage VMware ESX Server from a remote workstation using the VMware Remote Console and the VMware Management Interface.

Remote console software is available for Windows and Linux workstations. The remote console lets you attach directly to a virtual machine. You can start and stop programs, change the configuration of the guest operating system and do other tasks as if you were working at a physical computer.

Note: If you need secure communications between your management workstations and the server, be sure to choose the appropriate security level when you configure ESX Server. See Configuring Security Settings on page 206 for more information.

Registering Your Virtual Machines

If you create your virtual machines using the Virtual Machine Configuration Wizard, they are automatically registered in the file `/etc/vmware/vm-list` on the server's service console. The remote management software checks this file for pointers to the virtual machines you want to manage.

If you want to manage virtual machines that you set up in some other way, without using the wizard, you must first register them.

To do so, be sure the virtual machine is powered off. Then, on the Status Monitor page of the management interface, point to the terminal icon for the virtual machine you want to register and click **Edit Configuration**. Select **Registered** at the top of the Edit Configuration page.

Note: Registered virtual machines appear in the list only if their configuration files are stored locally on the ESX Server computer. If the configuration files are stored on an NFS-mounted drive, the virtual machines are not listed.

You can also register the virtual machines from the service console. To do so, use this command:

```
vmware-cmd -s register /<configpath>/<configfile>.vmx
```

To remove a virtual machine from the list, use this command:

```
vmware-cmd -s unregister /<configpath>/<configfile>.vmx
```

Installing the Remote Console Software

Use the package that corresponds to the operating system running on your management workstation and follow the installation steps below.

Installer files are available on the distribution CD-ROM. You may also download the appropriate installer from the Status Monitor page of the management interface.

Windows Clients

1. Find the installer file — `VMware-console-1.v.v-xxxx.exe` — on the distribution CD or in the directory where you downloaded it.
2. Double-click `VMware-console-1.v.v-xxxx.exe` to start the installation.
3. Follow the on-screen instructions.

Linux – RPM Installer

1. Find the installer file — `VMware-console-1.v.v-xxxx.i386.rpm` — on the distribution CD or in the directory where you downloaded it and change to that directory.
2. Become root.
   ```
   su -
   ```
3. Run the RPM installer.
   ```
   rpm -Uhv VMware-console-1.v.v-xxxx.i386.rpm
   ```

Linux – Tar Installer

1. Find the installer file — `VMware-console-1.v.v-xxxx.tar.gz` — on the distribution CD or in the directory where you downloaded it and copy it to the `/tmp` directory or another directory of your choice.
2. Become root.
   ```
   su -
   ```
3. Unpack the tar archive.
   ```
   tar zxf VMware-console-1.v.v-xxxx.tar.gz
   ```
4. Change to the directory where the archive was unpacked.
   ```
   cd vmware-console-distrib
   ```
5. Run the installer.
   ```
   ./vmware-install.pl
   ```

For information on running virtual machines from the remote console, see Running a Virtual Machine Using the Remote Console on page 181.

Third Party Software Compatibility

This section includes any special instructions for using a virtual machine with third-party middleware and management software.

Configuring a Virtual Machine for Use with Citrix MetaFrame XP

If you are using a Windows 2000 virtual machine as a MetaFrame XP server, be sure you are using FR1 or FR2, then complete the following steps to configure the virtual machine. If you are running MetaFrame XP in a Windows NT virtual machine, no special steps are needed.

1. Apply Citrix hotfix XE102W014.

   For a download link and instructions on applying the hotfix, go to the Citrix Web site (*http://www.citrix.com*), navigate to the support section and search for XE102W014.

2. Click **Save Changes** to save the configuration file.

For additional information on performance tuning, see article 869 in the VMware Knowledge Base.

Executing Scripts When the Virtual Machine's Power State Changes

You can run scripts in the guest operating system when you change the power state of a virtual machine; that is, when you power on, power off, suspend or resume the virtual machine.

Scripts can help automate guest operating system operations when you change the virtual machine's power state.

Note: There are no scripts for FreeBSD guest operating systems.

You perform these power operations from the toolbar buttons and menus in the consoles. For more information on changing the power state of a virtual machine in a console, see Special Power Options for Virtual Machines on page 182.

Scripts can run when using the power buttons in the VMware Management Interface. For more information, see Running the VMware Management Interface on page 87.

Scripts can be executed only when the VMware guest operating system service is running. The guest service starts by default when you start the guest operating system. For more information about the guest service, see About the VMware Guest Operating System Service on page 51.

Default scripts are included in VMware Tools. The default script executed when suspending a virtual machine stops networking for the virtual machine while the default script executed when resuming a virtual machine starts networking for the virtual machine.

In addition, you can create your own scripts. The scripts you can run must be batch files for Windows hosts but can be any executable format (such as shell or Perl scripts) for Linux hosts. You should have a thorough familiarity with these types of scripts before you modify the default scripts or create your own.

If you create your own scripts, you must associate each script with its particular power operation. For more information, see Choosing Scripts for VMware Tools to Run During Power State Changes on page 186.

In order for scripts and their associated power operations to work, the following conditions must be met:

1. The VMware guest operating system service must be running in the virtual machine.

2. The version of VMware Tools must be updated to the current version. If you are using a virtual machine created with an older version of VMware ESX Server or another older VMware product, update VMware Tools to the version included in this release.
3. Depending upon the operation the script performs, the virtual machine must have a virtual network adapter connected, otherwise the power operation fails.

Issues to Consider

When you reinstall VMware Tools after you upgrade the VMware ESX Server software, any changes you made to the default scripts are overwritten. Any scripts you created on your own remain untouched, but do not benefit from any underlying changes that enhance the default scripts.

Configuring Virtual Machines

Key configuration settings for an existing virtual machine can be changed from the VMware Management Interface. The virtual machine must be powered off when you change the configuration.

1. Log in to the server from the management interface (`http://<hostname>`) as a user who has rights to change the configuration file.
2. Click the name of the virtual machine you want to reconfigure.
3. On the Status Monitor page for that virtual machine, click **Hardware** or **Options** in the Configuration section.
4. Select a device or option to configure, then click **Edit**.
5. Make any changes you wish to the configuration, then click **OK**.

Details about changing these configuration settings are discussed in Configuring a Virtual Machine on page 106.

Caution: Only one user at a time should modify the configuration for a particular virtual machine.

You can modify other settings in the configuration. These settings include:

- Recommended Configuration Options on page 80
- Modifying the SMBIOS UUID on page 81
- Enabling the Physical Hardware's OEM ID to Be Seen by the Virtual Machine on page 84

To modify these settings in the configuration, manually edit the configuration file by doing one of the following:

- Use the configuration file editor in the VMware Management Interface. Point to the terminal icon for the virtual machine, then click the arrow to the right of the terminal icon and select **Configure Options**. Then, under Verbose Options, click the link. For more information, see Modifying the Configuration File Directly (Advanced Users Only) on page 141.
- Log into the service console and use a text editor there.

For purposes of illustration, we assume that you are working with the file `newvm.vmx` in a directory named `/virtual machines/vm1`.

Recommended Configuration Options

This section details options that can influence the performance of your virtual machines. These settings are not required to run VMware ESX Server correctly.

SleepWhenIdle

The configuration file option `monitor.SleepWhenIdle` determines whether the VMkernel deschedules an idle virtual machine. By default, this option is enabled, a setting that ensures much better performance when running multiple virtual machines.

When you are running only a single virtual machine (such as for benchmarking VMware ESX Server), add the `monitor.SleepWhenIdle` option to the virtual machine's configuration file if you want to achieve the best possible performance in the virtual machine (at the expense of responsiveness in the service console).

Create an option called `monitor.SleepWhenIdle` and set the value of this option to `0`, as described in Modifying the Configuration File Directly (Advanced Users Only) on page 141.

Optimizing Disk Access Failure Modes

ESX Server includes configuration options that allow you to optimize how virtual machines handle disk access failures. In particular, the `scsi<n>.returnBusyOnNoConnectStatus` option determines how ESX Server reports a failure to connect with a virtual SCSI adapter or failure to access it after initiating a connection. By setting the option to `TRUE` or `FALSE`, you can determine how the failure to access to a physical disk is represented to your virtual machine.

- If the option is set to `TRUE`, ESX Server returns the error message `SCSI BUSY`.
- If the option is set to `FALSE`, the value ESX Server returns depends on the type of SCSI controller you chose for that particular virtual device:
  - If you chose the BusLogic adapter (i.e., if **Virtual Device** is set to `vmxbuslogic`), your Virtual Machine receives the error message `DEVICE_NOT_THERE`.
  - If you chose the LSI Logic adapter (i.e., if **Virtual Device** is set to `vmxlsilogic`), your Virtual Machine receives the error message `BTSTAT_SELTIME0`.

You may need to set `returnBusyOnNoConnectStatus` to `FALSE` when disk management software operating in a virtual machine needs to detect access failures. For example, some types of disk mirroring software will not select a duplicate disk

unless they detect a discrete failure to access a primary disk. Reporting that a targeted disk is busy, rather than unavailable, may cause mirroring programs to repeat the connection attempt instead of selecting a duplicate disk.

ESX Server does not automatically include an explicit `returnBusyOnNoConnectStatus` option definition for each SCSI disk in a virtual machine. If the option is not defined for a disk in the virtual machine configuration file, ESX Server defaults to a value of `TRUE`. You need to both create an option definition for each disk and set it to `FALSE` if you wish to override the default value of `TRUE`. See Modifying the Configuration File Directly (Advanced Users Only) on page 141 for instructions.

Modifying the SMBIOS UUID

Each ESX Server virtual machine is automatically assigned a universally unique identifier (UUID), which is stored in the SMBIOS system information descriptor. It can be accessed by standard SMBIOS scanning software — for example SiSoftware Sandra or the IBM utility `smbios2` — and used for systems management in the same ways you use the UUID of a physical computer.

The UUID is a 128-bit integer. The 16 bytes of this value are separated by spaces except for a dash between the eighth and ninth hexadecimal pairs. So a sample UUID might look like this:

```
00 11 22 33 44 55 66 77-88 99 aa bb cc dd ee ff
```

Generating the UUID Automatically

The automatically generated UUID is based on the physical computer's identifier and the path to the virtual machine's configuration file. This UUID is generated when you power on or reset the virtual machine. The UUID that is generated remains the same so long as the virtual machine is not moved or copied.

The automatically generated UUID is also written to the virtual machine's configuration file as the value of `uuid.location`.

If you move or copy the virtual machine, a new UUID is generated when the virtual machine is powered on — based on the physical computer's identifier and path to the virtual machine's configuration file in its new location.

If you suspend and resume a virtual machine, this does not trigger the process that generates a UUID. Thus, the UUID in use at the time the virtual machine was suspended remains in use when the virtual machine is resumed, even if it has been copied or moved. However, the next time the virtual machine is rebooted, the UUID is generated again. If the virtual machine has been copied or moved, the UUID is changed.

In some circumstances — for example, if you are moving the virtual machine but want to keep the same UUID — you may want to assign a specific UUID to the virtual machine. In that case, you need to override the automatically generated UUID value. To do so, edit the virtual machine's configuration file as described in this section to set the value of the parameter `uuid.bios`.

Comparing the Generated UUID to Configuration File Parameters

When a virtual machine is powered on, ESX Server generates a UUID as described above and compares it to the values for `uuid.location` and (if it exists) `uuid.bios` in the configuration file.

If the automatically generated UUID matches the value of `uuid.location`, ESX Server checks for `uuid.bios`. If `uuid.bios` exists, its value is used as the virtual machine's UUID. If `uuid.bios` does not exist, the automatically generated value is used.

If the automatically generated UUID does not match the value of `uuid.location`, the newly generated value is used as the virtual machine's UUID and is saved to the configuration file, replacing the previous value of `uuid.location` and (if it exists) `uuid.bios`.

Note: Any changes to the UUID take effect only after the virtual machine is rebooted.

Setting the UUID for a Virtual Machine that Is Not Being Moved

To assign a specific UUID to a virtual machine that is not being moved, add one line to the configuration file. You may use the configuration file editor in the VMware Management Interface by completing one of the following:

- In the management interface, click the arrow to the right of the terminal icon for that virtual machine and select **Configure Options** in the virtual machine menu (see Using the Virtual Machine Menu on page 95), then click the link under Verbose Options. Create an option called `uuid.bios` and set the value as described below.
- Log in to the service console and, using a text editor there, open the virtual machine's configuration file (`.vmx`). Add the following line:
  `uuid.bios = <uuidvalue>`

The UUID value (`<uuidvalue>`) must be surrounded by quotation marks. A sample configuration option might look like this:

```
uuid.bios = "00 11 22 33 44 55 66 77-88 99 aa bb cc dd ee
ff"
```

After adding this option to the configuration file, restart the virtual machine. The new UUID is used when the virtual machine restarts.

Setting the UUID for a Virtual Machine that Is Being Moved

If you plan to move a virtual machine and want it to have the same UUID it did before the move, you must note the UUID being used before the move and add that UUID to the configuration file after the move. Follow these steps:

1. Before moving the virtual machine, examine its configuration file. Complete one of the following:
   - In the management interface, click the arrow to the right of the terminal icon for that virtual machine and select **Configure Options** in the virtual machine menu (see Using the Virtual Machine Menu on page 95), then click the link under Verbose Options.
   - Log in to the service console and, using a text editor there, open the virtual machine's configuration file (`.vmx`).

   If the virtual machine's UUID has been set to a specific value, the configuration file has a line that begins with `uuid.bios`. Note the 128-bit hexadecimal value that follows. This is the value you should use in the new location.

   If there is no line beginning with `uuid.bios`, look for the line that begins with `uuid.location` and note the 128-bit hexadecimal value that follows it.
2. Move the virtual machine's disk (`.dsk`) file to the new location.
3. Use the management interface to create a new virtual machine configuration and set it to use the virtual disk file you moved in the previous step.
4. Edit the virtual machine's configuration file to add a `uuid.bios` line, as described in Setting the UUID for a Virtual Machine that Is Not Being Moved on page 82. Set the value of `uuid.bios` to the value you recorded in step 1. Also, remove the `uuid.location` line in the virtual machine's configuration file.
5. Start the virtual machine. It should now have the same UUID as it did before the move.

Enabling the Physical Hardware's OEM ID to Be Seen by the Virtual Machine

Each virtual machine is automatically assigned an Original Equipment Manufacturer ID (OEMID), comprising the Manufacturer and Product Name, which is stored in the SMBIOS system information descriptor. It can be accessed by standard SMBIOS scanning software — for example SiSoftware Sandra or the IBM utility `smbios2` — and used for systems management in the same way you use the OEMID of a physical computer.

By default, the Manufacturer string is "VMware, Inc." and the Product Name string is "VMware Virtual Platform".

If the virtual machine's configuration file has the option

```
SMBIOS.reflectHost = TRUE
```

then the Manufacturer and Product Name strings in the virtual machine are the same as the Manufacturer and Product Name of the host system.

These strings are updated (copied from the host BIOS to the virtual machine BIOS) on every virtual machine BIOS POST (Power On Self Test).

CHAPTER 3

Using the VMware Management Interface to Manage Your Virtual Machines

The following sections describe various aspects of using the VMware Management Interface:

- Running the VMware Management Interface on page 87
- Configuring the Statistics Period for the VMware Management Interface on page 89
- Using Internet Explorer 6.0 to Access the VMware Management Interface on page 90
- Logging Into the VMware Management Interface on page 92
- Using the Status Monitor on page 93
- Configuring a Virtual Machine on page 106
- Modifying Virtual Machine Peripherals on page 147
- Deleting a Virtual Machine Using the VMware Management Interface on page 153
- Managing ESX Server Resources on page 155
- Configuring VMware ESX Server on page 156

- Logging Out of the VMware Management Interface on page 157
- Using the Apache Web Server with the Management Interface on page 158
- Setting a MIME Type to Launch the VMware Remote Console on page 159
- Editing a Virtual Machine's Configuration File Directly on page 161
- Using the VMware Management Interface File Manager on page 163
- Registering and Unregistering Virtual Machines on page 168
- Running Many Virtual Machines on ESX Server on page 170
- Backing Up Virtual Machines on page 174

Running the VMware Management Interface

VMware ESX Server provides the VMware Management Interface, a Web-based management tool that allows you to

- Monitor the state of virtual machines and the VMware ESX Server machine on which they are running.
- Control (power on, suspend, resume, reset and power off) the virtual machines on the server.
- Connect the VMware Remote Console to a given virtual machine, for hands-on management.
- Modify virtual machine configurations.
- Manage users and groups.
- Configure SANs.
- Create and delete virtual machines.
- Answer questions and acknowledge messages posed by the virtual machine.
- Configure ESX Server (root users only).

You should use the VMware Management Interface from a management workstation, not from the server machine where ESX Server is installed. Running the X Windows System on your server's service console is not recommended.

To use the management interface, make sure you set **read** permissions for all users for each virtual machine you want to manage from a browser when you register each virtual machine.

Note: If you are connecting to the management interface with Internet Explorer 6.0, you must configure the browser. See Using Internet Explorer 6.0 to Access the VMware Management Interface on page 90.

Note: You can only use ASCII characters when viewing the management interface.

Once your user name and password are authorized by the management interface, the Status Monitor page appears. The Status Monitor page contains high level details about all the virtual machines on the server to which you are connected. The Status Monitor page links to a detailed set of pages specific to each virtual machine, where you find information about virtual devices, configuration options and a summary of

recent events. In addition, you can create and delete virtual machines from your browser.

These pages refresh or reload automatically, refreshing every 90 seconds. You may want to refresh or reload these pages manually before you perform an operation like suspending, resuming, or powering on or off a virtual machine from the management interface — or after you perform a power operation in a remote console — in case another user has performed the same or a conflicting operation right before you. To refresh the page, click **Refresh** at the top of a page.

Note: Your management interface sessions times out after a 60 minute period of idle time.

This setting is represented by the variable `vmware_SESSION_LENGTH`, stored in `/home/vmware/mui/apache/conf/access.conf`. You can block access to the management interface for all users by setting `vmware_SESSION_LENGTH` to `0` minutes. On the other hand, you can allow for persistent sessions that never time out by setting `vmware_SESSION_LENGTH` to `-1`.

Configuring the Statistics Period for the VMware Management Interface

By default, the VMware Management Interface provides statistics about the server and virtual machines that reflect the past five minutes of activity. The statistics get updated every 20 seconds.

You can configure this setting for a period of one minute to see more usage details or you can configure it for a period of 15 minutes to smooth out short-term spikes. Increasing the statistics period changes the update frequency to every minute instead of every 20 seconds; it also reduces the amount of load on the service console, improving the performance of a server running a large number of virtual machines.

To configure the statistics period for the management interface, do the following.

1. Connect to the service console with a terminal.
2. Edit the file `/usr/lib/vmware-mui/apache/conf/access.conf`.
3. Under the line that states `PerlSetEnv vmware_SESSION_LENGTH 60`, do one of the following.
   - `To set the period to one minute, add this line: PerlSetEnv vmware_STATS_PERIOD 1`
   - `To set the period to 15 minutes, add this line: PerlSetEnv vmware_STATS_PERIOD 15`
4. Save and close the file.
5. Restart Apache for the change to take effect.
   `/etc/init.d/httpd.vmware restart`

Using Internet Explorer 6.0 to Access the VMware Management Interface

If you intend to run the VMware Management Interface in Internet Explorer 6.0 on a Windows management workstation, you must take certain steps to configure Internet Explorer properly.

The configuration steps allow you to perform the following activities:

- Launching the Remote Console from the Management Interface on an Encrypted Server on page 90
- Connecting to the Management Interface On a Proxy Server on page 91

Launching the Remote Console from the Management Interface on an Encrypted Server

You can launch the VMware Remote Console from the VMware Management Interface automatically. In order to do this in an Internet Explorer 6.0 browser on a Windows system where SSL is encrypting your ESX Server remote connections, you must ensure that the **Do not save encrypted pages to disk** option is disabled.

For information on encrypting remote connections, see Configuring Security Settings on page 229.

When this option is enabled, Internet Explorer does not save any files to disk, including the files it needs to hand off to helper applications. This prevents the remote console from launching automatically.

Caution: This option may have been enabled deliberately at your site to prevent the saving of sensitive files to disk. Disabling it may permit other sensitive information to be saved to disk.

To disable the option, complete the following steps.

1. In the Internet Explorer 6.0 window, open the Internet Options control panel. Choose **Tools** > **Internet Options**.
2. Click the **Advanced** tab.
3. Scroll down to the Security section and uncheck **Do not save encrypted pages to disk**.
4. Click **OK**.

Connecting to the Management Interface On a Proxy Server

If your network is protected behind a proxy server, there are certain steps you must take in order to use the management interface in Internet Explorer 6.0 on a Windows system. Follow the steps for the appropriate Windows operating system.

Windows Server 2003 Systems

1. Launch Internet Explorer 6.0.
2. Choose **Tools** > **Internet Options**, then click the **Security** tab.
3. Select **Trusted sites**, then click **Sites**.
4. In the **Add this Web site to the zone** entry field, type `https://*.domain.com`
5. Click **Add**.
6. Click **OK** until you return to the browser window.

When you use Internet Explorer 6.0 to connect to the management interface, be sure to use fully qualified domain names.

Windows Systems Other than Windows Server 2003

Follow these steps for Windows 2000, Windows XP and Windows NT operating systems.

1. Launch Internet Explorer 6.0.
2. Choose **Tools** > **Internet Options**.
3. Click the **Connections** tab, then click **LAN Settings**.
4. Make sure that **Bypass proxy server for local addresses** is checked.
5. Click **OK** until you return to the browser window.

When you use Internet Explorer 6.0 to connect to the management interface, do **not** use fully qualified domain names.

Connecting to the Management Interface when there Is No Proxy Server

If you are on a Windows system and your network does not use a proxy server, you must use fully-qualified domain names when connecting to the management interface with Internet Explorer 6.0.

Logging Into the VMware Management Interface

To use the VMware Management Interface, you should be running:

- Internet Explorer 5.5 (Internet Explorer 6.0 or higher is strongly recommended)
- Netscape Navigator 7.0 or higher
- Mozilla 1.x. or higher

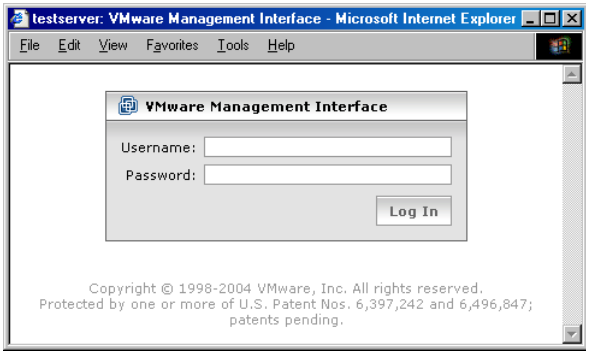
You need to know the server name or IP address of the server you want to manage. You must have a valid user name and password on that server.

You can connect to the server with up to eight management interface sessions at a time.

The URL to connect to the server is `http://<hostname>`.

If you are using Netscape Navigator or Mozilla, check the advanced preferences (**Edit** > **Preferences** > **Advanced**) to be sure JavaScript and style sheets are both enabled. You need to know the host name or IP address of the server you want to monitor. You should also ensure that style sheets are enabled in your browser, regardless of which browser and version you are using.

The Login page appears.

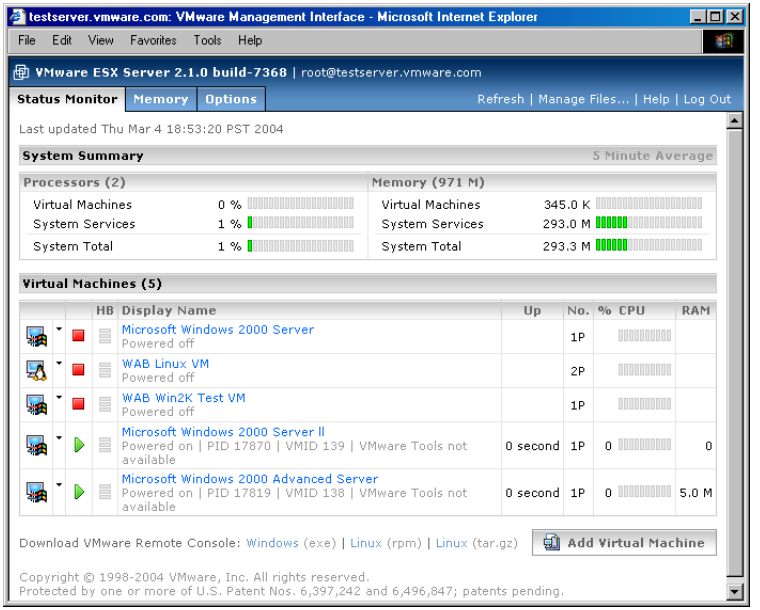

testserver: VMware Management Interface - Microsoft Internet Explorer
File Edit View Favorites Tools Help
VMware Management Interface
Username:
Password:
Log In
Copyright © 1998-2004 VMware, Inc. All rights reserved.
Protected by one or more of U.S. Patent Nos. 6,397,242 and 6,496,847;
patents pending.

The Login page contains fields for your user name and password.

On the Login page, enter your user name and password for the host machine, then click **Login**. The Status Monitor page appears. For information about the Status Monitor page, see Using the Status Monitor on page 93.

Using the Status Monitor

The Status Monitor page contains a high-level view of VMware ESX Server including a server system summary and list of all registered virtual machines.


testserver.vmware.com: VMware Management Interface - Microsoft Internet Explorer
File Edit View Favorites Tools Help
VMware ESX Server 2.1.0 build-7368 | root@testserver.vmware.com
Status Monitor
Memory
Options
Refresh | Manage Files... | Help | Log Out
Last updated Thu Mar 4 18:53:20 PST 2004
System Summary
5 Minute Average
Processors (2)
Virtual Machines 0 %
System Services 1 %
System Total 1 %
Memory (971 M)
Virtual Machines 345.0 K
System Services 293.0 M
System Total 293.3 M
Virtual Machines (5)
HB Display Name Up No. % CPU RAM
Microsoft Windows 2000 Server
Powered off
1P
WAB Linux VM
Powered off
2P
WAB Win2K Test VM
Powered off
1P
Microsoft Windows 2000 Server II
Powered on | PID 17870 | VMID 139 | VMware Tools not available
0 second 1P 0 0
Microsoft Windows 2000 Advanced Server
Powered on | PID 17819 | VMID 138 | VMware Tools not available
0 second 1P 0 5.0 M
Download VMware Remote Console: Windows (exe) | Linux (rpm) | Linux (tar.gz)
Add Virtual Machine
Copyright © 1998-2004 VMware, Inc. All rights reserved.
Protected by one or more of U.S. Patent Nos. 6,397,242 and 6,496,847; patents pending.

Viewing Summary Information about VMware ESX Server

Under **System Summary**, you can view:

- The number of processors on ESX Server, including the average percentage of CPU usage used by virtual machines and the service console and the total being used by the whole system for the previous five minutes.
- The amount of memory on ESX Server, including the average amount of memory used by virtual machines, other processes on the server and the total being used by the whole system for the previous five minutes.

Note: The period of time these statistics cover can be modified. See Configuring the Statistics Period for the VMware Management Interface on page 89.

Viewing Summary Information about Virtual Machines on VMware ESX Server

Under **Virtual Machines**, you can view a list of all registered virtual machines on the host. When a virtual machine is running, the Status Monitor page displays its ID number after the power status of the virtual machine.

Note: Virtual machines may not appear in the list, if their configuration files are stored on an NFS-mounted drive. When a virtual machine's configuration file is on an NFS-mounted drive, the root user is often unable to access the file since root privileges are not allowed. Also, you cannot see the virtual machines if the NFS directory is not mounted.

Activities you can perform include:

- Connecting to a Virtual Machine with the VMware Remote Console on page 94
- Using the Virtual Machine Menu on page 95
- Changing the Power State of a Virtual Machine on page 96
- Suspending and Resuming Virtual Machines on page 97
- Viewing Information about a Virtual Machine on page 103
- Downloading Remote Management Packages on page 104 (Status Monitor page only)
- Creating a New Virtual Machine on page 104 (Status Monitor page only)
- Unregistering a Virtual Machine on page 104
- Deleting a Virtual Machine on page 104
- Configuring VMware ESX Server on page 104 (Options page only)
- Using Common Controls on page 105

Connecting to a Virtual Machine with the VMware Remote Console

If you need to view a particular virtual machine's desktop, you can attach the VMware Remote Console and connect to the virtual machine. Click the terminal icon ( ) to launch the remote console. For more information on connecting the remote console, see Using the Remote Console on page 180.

Netscape and Mozilla users must define a MIME type for the console first; Internet Explorer is automatically configured when the remote console is installed. For more information, see Setting a MIME Type to Launch the VMware Remote Console on page 159.

The terminal icon appears slightly differently, depending upon the guest operating system installed in the virtual machine. This visual cue helps to identify the virtual machine, for example, when the display name does not indicate the guest operating system. Below are the different ways the terminal icon appears in the management interface.

— indicates a Windows guest operating system.

— indicates a Linux guest operating system.

— indicates a NetWare guest operating system.

— indicates other guest operating systems.

Using the Virtual Machine Menu

Click the arrow to the right of the terminal icon ( ) to display a menu of options for the virtual machine. The menu includes the following commands, most of which can be performed using the buttons and other visual elements of the management interface. Depending on your permissions and the state of the virtual machine, some options may not be available.

- **Attach Remote Console** — launches the VMware Remote Console, which connects to this virtual machine. This is the same as clicking . You need to log in to the host. For more information, see Using the Remote Console on page 180.

  Note: Netscape and Mozilla users must define a MIME type for the console first; Internet Explorer is automatically configured when the remote console is installed. For information, see Setting a MIME Type to Launch the VMware Remote Console on page 159.

- **Properties** — opens the Status Monitor page for this virtual machine in a new browser window. This is the same as clicking the display name link in the **Display Name** column.

- **Configure Hardware** — opens the Hardware page, where you can edit a virtual machine's hardware configuration. You can edit most configuration options only when the virtual machine is powered off. When the virtual machine is powered on, you can edit removable devices and the virtual network adapter.

  For more information, see Configuring a Virtual Machine's Hardware on page 116.

- **Configure Options** — opens the Options page, where you can edit a virtual machine's standard information, such as guest operating system, display name

and the location of the suspended state file. With the exception of the display name, you can edit these options only when the virtual machine is powered off.

For more information, see Setting Standard Virtual Machine Configuration Options on page 138.

- **Shut Down Guest** — shuts down the guest operating system, powers off the virtual machine then runs the script associated with this power state change. This is the same as clicking in the power state popup.
- **Suspend after Running Script** — runs the associated script then suspends a running virtual machine. This is the same as clicking in the power state popup.
- **Power On/Resume and Run Script** — powers on a stopped virtual machine or resumes a suspended virtual machine, then runs the script associated with this power state change. This is the same as clicking in the power state popup.
- **Restart Guest** — restarts the guest operating system and the virtual machine. This is the same as clicking in the power state popup.
- **Power Off** — powers off the virtual machine immediately without running a script. This is the same as turning off the power to a physical computer.
- **Suspend** — suspends a powered on virtual machine without running a script.
- **Power On/Resume** — powers on a stopped virtual machine or resumes a suspended virtual machine without running a script.
- **Reset** — resets the virtual machine immediately without running a script. This is the same as pressing the reset button on a physical computer.
- **Unregister Virtual Machine** — unregisters the virtual machine. The virtual machine no longer appears on the Status Monitor page so it cannot be managed or accessed. For information on registering virtual machines, see Registering and Unregistering Virtual Machines on page 168.
- **Delete Virtual Machine** — lets you delete a virtual machine or just its configuration, provided the virtual machine is powered off. See Deleting a Virtual Machine Using the VMware Management Interface on page 153.

Changing the Power State of a Virtual Machine

Depending upon your permissions, you can change the power state of the virtual machine in the management interface. Your permissions are listed in the **Users and Events** tab for the virtual machine. For more information, see Viewing a List of Connected Users on page 144.

To change the virtual machine's power state, click the button that indicates the virtual machine's current power state. A popup menu appears, displaying the following buttons:

Button	Description
	Shuts down the guest operating system and powers off the virtual machine. VMware ESX Server closes any open applications and shuts down the guest operating system before powering off the virtual machine. VMware Tools executes the script associated with this power state change, if any. When this icon is red, the virtual machine is powered off.
	Suspends a running virtual machine or resumes a suspended virtual machine. VMware Tools executes the script associated with this power state change, if any. When this icon is amber, the virtual machine is suspended.
	Powers on a stopped virtual machine or resumes a suspended virtual machine. VMware Tools executes the script associated with this power state change, if any. When this icon is green, the virtual machine is running.
	Restarts a guest operating system. VMware ESX Server closes any open applications and shuts down the guest operating system before restarting the guest operating system.

Changing the power state executes any script associated with the power state change. For more information about running scripts, see Choosing Scripts for VMware Tools to Run During Power State Changes on page 186.

Suspending and Resuming Virtual Machines

This section contains the following:

- Setting the Suspend Directory on page 98
- Enabling Repeatable Resume on page 99

You can suspend and resume a virtual machine with the management interface. See Changing the Power State of a Virtual Machine on page 96. You can also suspend and resume a virtual machine from a remote console. See Suspending and Resuming Virtual Machines on page 189.

Suspending a virtual machine, then later resuming its operation, can speed provisioning tasks — for example, deployment of standby servers. VMware ESX Server supports two configurations for resuming a suspended virtual machine.

- You can suspend a running virtual machine at any time, then resume operation, suspend at a later time, then resume with the machine in the second state, and so on.

- You can suspend a virtual machine at any desired point in its operation, then lock in the suspended state at that chosen point. Any time you restart the virtual machine, it resumes in the same state — the state it was in when you first suspended it.

Note: You should not change a configuration file after you suspend a virtual machine, since the virtual machine does not resume properly if the configuration file is inconsistent with the suspended virtual machine. Also, you should not move any physical disks or change the name of any VMFS file systems that the virtual machine uses. If you do, the virtual machine will not be able to access its virtual disks when it resumes.

You can also set the configuration of each virtual machine so the file that stores information on the suspended state is saved in a location of your choice.

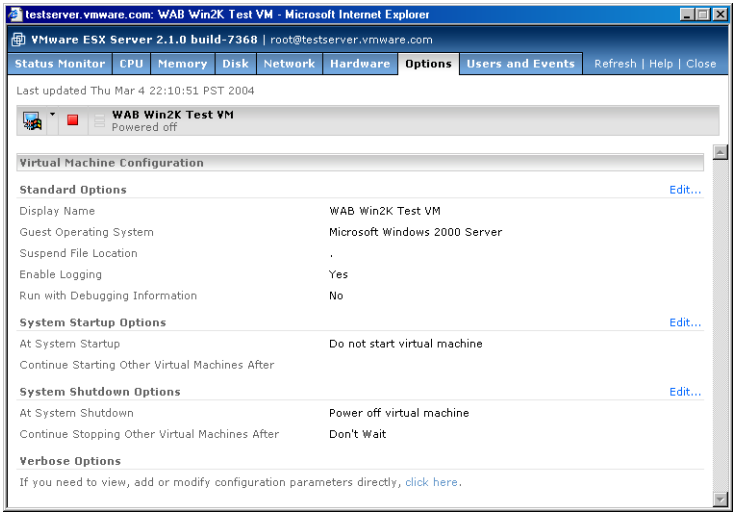
Setting the Suspend Directory

When a virtual machine is suspended, its state is written to a file with a `.vmss` extension. By default, the `.vmss` file is written to a VMFS volume. Similarly, when a virtual machine is being resumed, ESX Server looks for the `.vmss` file in the same VMFS volume.

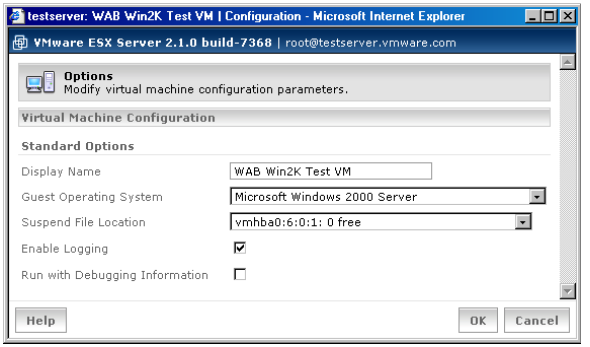
When you change the directory where the suspended state file for a virtual machine is stored, the virtual machine must be powered off. Then follow these steps:

1. Log into the VMware Management Interface, then click the arrow to the right of the terminal icon ( ) for the virtual machine you want to change and choose Configure Options.

The Options page for this virtual machine appears in a new browser window.



2. Click **Edit**. The Edit Options page appears.



For fastest suspend and restore operations, select the appropriate VMFS volume from the **Suspend File Location** list. ESX Server automatically adds a suffix to the name of the suspended state file to ensure that one virtual machine does not overwrite the suspended state file of another.

3. Click **OK** to save your changes.

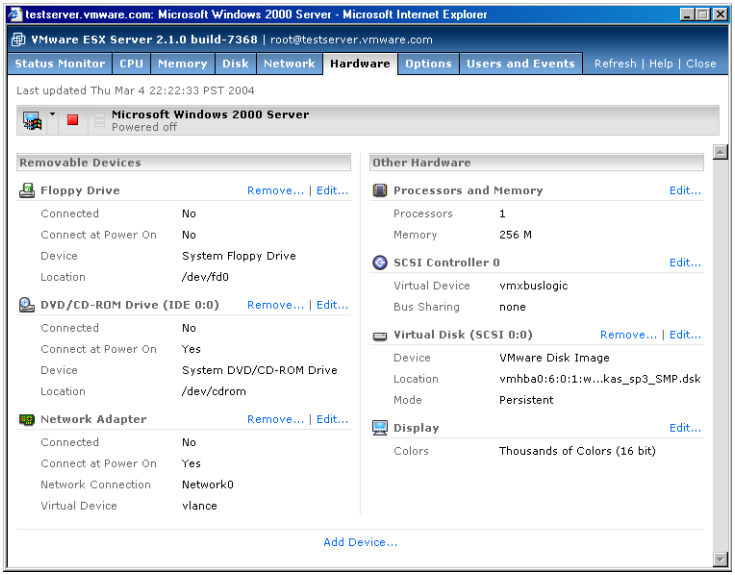
Enabling Repeatable Resume

When you suspend a virtual machine in the usual way, by clicking the **Suspend** button on the remote console or in the management interface, ESX Server writes a file

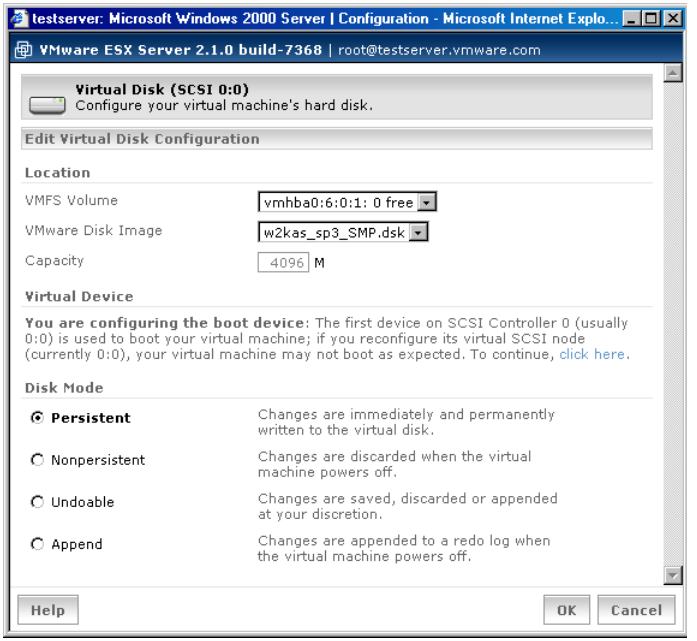
with a `.vmss` extension. This file contains the entire state of the virtual machine. When the virtual machine is resumed, its state is restored from the `.vmss` file. The `.vmss` file is then modified while the virtual machine is running. This means that, in normal operation, the `.vmss` file cannot be used to resume a virtual machine again from the original suspended state.

If you do want to be able to resume a virtual machine in the same state repeatedly — for example, to have a hot-standby virtual machine in a particular state so it is ready to take over for a failed server — take the following steps:

1. Shut down and power off the virtual machine. In the management interface, open the virtual machine menu. Click the arrow next to the terminal icon ( ) and select **Configure Hardware**.

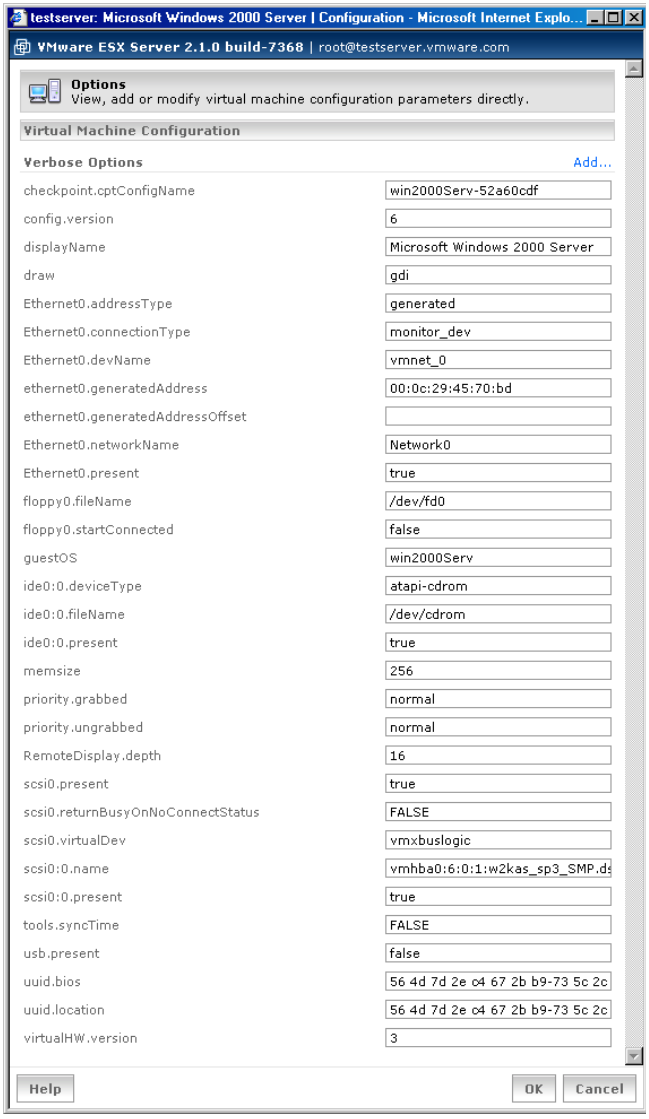


2. Next to Virtual Disk, click **Edit**.


testserver: Microsoft Windows 2000 Server | Configuration - Microsoft Internet Explo...
VMware ESX Server 2.1.0 build-7368 | root@testserver.vmware.com
Virtual Disk (SCSI 0:0)
Configure your virtual machine's hard disk.
Edit Virtual Disk Configuration
Location
VMFS Volume
vmhba0:6:0:1: 0 free
VMware Disk Image
w2kas_sp3_SMP.dsk
Capacity
4096 M
Virtual Device
You are configuring the boot device: The first device on SCSI Controller 0 (usually 0:0) is used to boot your virtual machine; if you reconfigure its virtual SCSI node (currently 0:0), your virtual machine may not boot as expected. To continue, click here.
Disk Mode
Persistent
Changes are immediately and permanently written to the virtual disk.
Nonpersistent
Changes are discarded when the virtual machine powers off.
Undoable
Changes are saved, discarded or appended at your discretion.
Append
Changes are appended to a redo log when the virtual machine powers off.
Help
OK
Cancel

3. Click **Nonpersistent**, then click **OK** to save your change.

4. Click the **Options** tab, then under Verbose Options, click the link. The configuration file opens in an editor.



5. Click **Add**, then create an option called `resume.repeatable` and set its value to `TRUE`.
6. Click **OK** to save and close the configuration file.
7. Power on the virtual machine.
8. Using the remote console, take the steps necessary to reach the state in which you want to suspend the virtual machine.
9. Click **Suspend** to activate repeatable resume.
10. After you do this, each time you resume the virtual machine, it will resume from the suspend point you have set. When you click **Power Off**, the virtual machine will power off, ready to resume at the suspend point you have set.

If you no longer want to resume the virtual machine using the repeatable resume point, shut down the virtual machine and manually remove the suspended state (`.std`) file from the virtual machine directory. Once it is deleted, you may suspend the virtual machine in a new state to create a new repeatable resume point; otherwise, you can set the `resume.repeatable` flag to `FALSE` in the configuration file.

Viewing Information about a Virtual Machine

Important virtual machine information is readily available on the Status Monitor page.

- The link in the **Display Name** column indicates the display name for the virtual machine; if one is not specified, then the path to the configuration file for the virtual machine appears here instead. This column also contains the virtual machine's power state and its process ID and virtual machine ID (if it is running); it also notes if VMware Tools is not installed.

  If the virtual machine is waiting for a response to a system message, a "Waiting for input" link appears here. Click the link to view the message and respond to it.

  Click the virtual machine name link for more details about the virtual machine. The virtual machine's Status Monitor page appears in a new browser window. For more information, see Configuring a Virtual Machine on page 106.
- The value in the **Up** column indicates the length of time the virtual machine has been running.
- The value in the **No.** column indicates the number of virtual processors in the virtual machine.
- The value in the **% CPU** column indicates the average percentage of host operating system processor capacity the virtual machine used during the final

minute before the page was last updated. More detailed processor information is available on the Status Monitor page.

- The value in the **RAM** column indicates the amount of memory allocated to the virtual machine. For more information about memory usage, see Configuring a Virtual Machine's Memory Usage on page 110. For general information on memory, see Virtual Machine Memory on page 425.

Downloading Remote Management Packages

You can download a remote management package from the VMware Management Interface Status Monitor page.

To download a remote console package from the Status Monitor page, click the link at the bottom of the page for the appropriate installation file. This allows you to quickly download the console you need without logging out of the management interface.

Creating a New Virtual Machine

To create a new virtual machine from the management interface, on the Status Monitor page, click **Add Virtual Machine**. The Add Virtual Machine wizard starts. For information on creating a virtual machine from the management interface, see Creating a New Virtual Machine on page 38.

Unregistering a Virtual Machine

You can unregister a virtual machine so it no longer appears on the Status Monitor page and cannot be managed or accessed. For information on registering virtual machines, see Registering and Unregistering Virtual Machines on page 168.

Deleting a Virtual Machine

To delete a virtual machine from the management interface, click the arrow to the right of the terminal icon ( ) and choose **Delete Virtual Machine**. The Confirm: Deleting <Virtual Machine> page appears in a new window. For information on deleting a virtual machine from the management interface, see Deleting a Virtual Machine Using the VMware Management Interface on page 153.

Configuring VMware ESX Server

The **Options** tab lets you make changes to your VMware ESX Server configuration. For more information, see Configuring VMware ESX Server on page 156 and Administering ESX Server on page 215.

Note: Only a user with root privileges can access this tab.

Using Common Controls

In addition, the following links appear on most or all of the pages in the management interface.

Refresh — This link refreshes or reloads the current page. To avoid conflicts with other users, click this button before you perform an operation in the management interface like shutting down, suspending, resuming or powering on a virtual machine — or **after** you perform such an operation in a remote console.

Manage Files — This link opens the management interface's file manager. The file manager lets you can manage the file system of your VMware ESX Server machine remotely. See Using the VMware Management Interface File Manager on page 163.

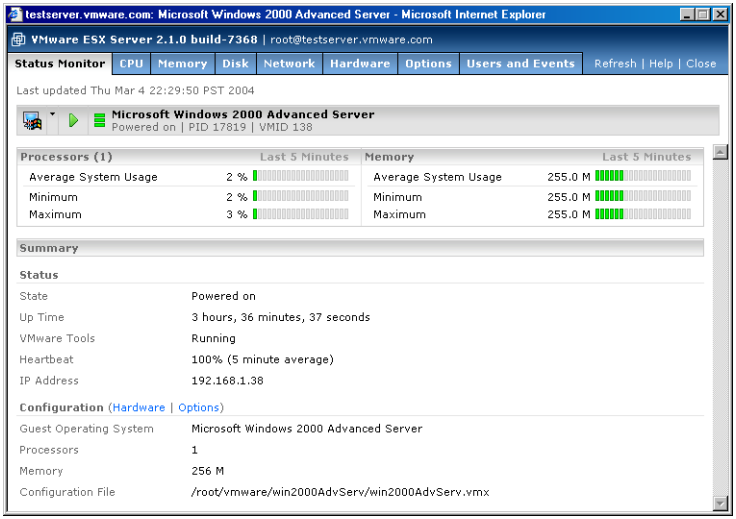
Help — This link connects you to the VMware ESX Server online documentation for the current page in the management interface.

Logout — This link logs you out of the management interface. You can only log out from the Status Monitor and Options pages. Click **Logout** to return to the Login page. See Logging Out of the VMware Management Interface on page 157.

Close — Closes the current management interface window. You can only close windows on the Add Virtual Machine and virtual machine details pages.

Configuring a Virtual Machine

To see more information about a particular virtual machine and to modify its configuration, click the link to the virtual machine in the **Display Name** column on the Status Monitor page. The Status Monitor page appears in a new browser window.



The Status Monitor page contains the following information:

- The current power state of the virtual machine — whether it is powered on, powered off or suspended.
- The process ID of the virtual machine.
- The VMID of the virtual machine, which is the `vmkernel` version of the PID for a running virtual machine.
- The minimum, maximum and average percentage of server processor capacity that the virtual machine used in the previous five minutes.

  Note: The period of time these statistics cover can be modified. See Configuring the Statistics Period for the VMware Management Interface on page 89.
- The minimum, maximum and average amount of server memory that the virtual machine used in the previous five minutes.

Note: The period of time these statistics cover can be modified. See Configuring the Statistics Period for the VMware Management Interface on page 89.

- How long the virtual machine has been running.
- VMware Tools status; whether VMware Tools is installed and running.
- The average percentage of heartbeats received by a virtual machine during the previous minute. The heartbeats are sent by the VMware guest operating system service to the virtual machine from its guest operating system; the percentage is relative to the number of heartbeats the virtual machine expects to receive for the minute before the page was last updated. Heavily loaded guest operating systems may not send 100% of the expected heartbeats, even though the system is otherwise operating normally; in general, only when the heartbeat percentage drops to zero should the virtual machine or guest operating system be considered abnormal.

  Note: If VMware Tools is not installed or is not running, the guest operating system does not send any heartbeats to its virtual machine and **Not Available** appears here.
- The IP address of the virtual machine.
- Links to edit the virtual machine's hardware and standard configuration options. Click **Hardware** to edit the virtual machine's hardware. The Hardware page appears. Click **Options** to edit the virtual machine's standard configuration options. The Options page appears. You can make changes to the virtual machine's configuration in these places. To change most options, the virtual machine must be powered off.
- The guest operating system installed in the virtual machine.
- The number of virtual processors in the virtual machine.
- The amount of memory allocated to the virtual machine.
- The path to the virtual machine's configuration file on the ESX Server system.

Activities you can perform when viewing a virtual machine's details include:

- Editing a Virtual Machine's Configuration on page 108
- Configuring a Virtual Machine's CPU Usage on page 108
- Configuring a Virtual Machine's Memory Usage on page 110
- Configuring a Virtual Machine's Disk Usage on page 113
- Configuring a Virtual Machine's Networking Settings on page 114

- Configuring a Virtual Machine's Hardware on page 116
- Setting Standard Virtual Machine Configuration Options on page 138
- Viewing a List of Connected Users on page 144
- Viewing a Log of a Virtual Machine's Events on page 145
- Connecting to a Virtual Machine with the VMware Remote Console on page 94
- Using the Virtual Machine Menu on page 95
- Changing the Power State of a Virtual Machine on page 96
- Using Common Controls on page 105

Editing a Virtual Machine's Configuration

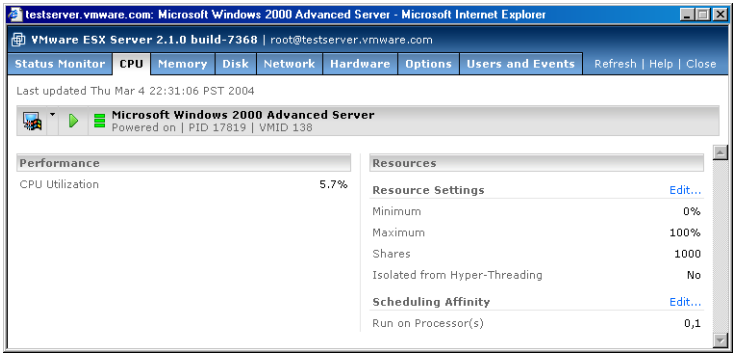
You can edit a virtual machine's configuration from the management interface by doing one of the following:

- On the Status Monitor page, click **Hardware** or **Options**. The virtual machine must be powered off before you can edit most configuration options.
- On the Status Monitor or a details page for that virtual machine, click the arrow to the right of the terminal icon ( ) and select **Configure Hardware** or **Configure Options** in the Virtual Machine menu (see Using the Virtual Machine Menu on page 95.)

A new browser window appears, allowing you to make changes to the virtual machine's configuration.

Configuring a Virtual Machine's CPU Usage

To review and configure the virtual machine's processor usage, click the **CPU** tab. The CPU page appears.



The CPU page shows how much of the server processor or processors each virtual processor is utilizing, how CPU resources are allocated to the virtual machine, whether Hyper-Threading is enabled and if there is any scheduling affinity to any specified processors on the server.

Understanding Performance Values

The values under Performance are based on the past five minutes. The period of time these statistics cover can be modified. See Configuring the Statistics Period for the VMware Management Interface on page 89. Performance information displayed includes:

- **CPU Utilization** — how much of the server processor or processors each virtual processor is utilizing.

Understanding Resource Values

The values under Resources indicate a range of percentages of a processor to which the virtual machine is entitled. Resource information displayed includes:

- **Minimum** — represents the minimum amount of processor capacity that must be available in order to power on the virtual machine.
- **Maximum** — represents the highest amount of processor capacity the virtual machine can ever consume, even if the processor is idle. The maximum value can be larger than 100% if the virtual machine has more than one virtual CPU.
- **Shares** — represents a relative metric for allocating processor capacity. The values **low**, **normal**, and **high** are compared to the sum of all shares of all virtual machines on the server and the service console. Share allocation symbolic values can be used to configure their conversion into numeric values.
- **Isolated from Hyper-Threading** — represents the CPU operation state of the virtual machine. Enabling this option prevents a virtual machine from sharing a physical CPU with other virtual machines when Hyper-Threading is enabled.

  Note: Enabling this option prevents the virtual machine from using the performance advantages of Hyper-Threading.

For more information on share values, refer to the resource management man pages: `cpu(8)`, `diskbw(8)`, and `mem(8)`. For more information on Hyper-Threading, see the `hyperthreading(8)` man page.

- **Scheduling Affinity** — represents on which ESX Server processors the virtual machine can run, when the ESX Server system is a multiprocessor system.

Modifying CPU Values

These values can be modified. Click **Edit**. For information on changing CPU settings, see Allocating CPU Resources on page 388.

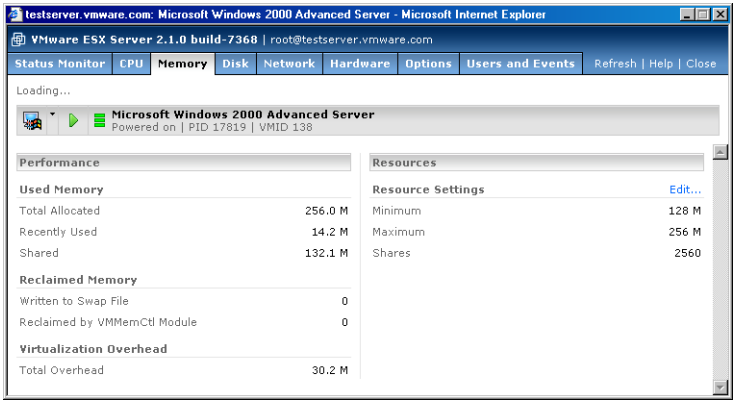
Other activities you can perform when configuring a virtual machine's CPU information include:

- Connecting to a Virtual Machine with the VMware Remote Console on page 94
- Using the Virtual Machine Menu on page 95
- Changing the Power State of a Virtual Machine on page 96
- Using Common Controls on page 105

Click the tabs at the top of the page to view more information about the virtual machine.

Configuring a Virtual Machine's Memory Usage

To review and configure the virtual machine's memory usage, click the **Memory** tab. The Memory page appears.



The Memory page shows how much memory is being used by the virtual machine and how memory resources are allocated to the virtual machine.

Understanding Performance Values

The values under Performance are based on the past five minutes. The period of time these statistics cover can be modified. See Configuring the Statistics Period for the VMware Management Interface on page 89. Performance information displayed includes

- Used Memory — value which represents the amount of memory allocated to the virtual machine when it was configured, how much memory has been used recently by the virtual machine and how much memory has been shared between all running virtual machines on the server and within the virtual machine itself.
- Reclaimed Memory — value which represents how much memory has been reclaimed by ESX Server under heavy loads or when you are overcommitting memory.
- Virtualization Overhead — represents how much extra memory the virtual machine process is using, in addition to the amount of memory allocated to it.

Understanding Resource Values

The values under Resources indicate a range of system memory to which the virtual machine is entitled. Resource information displayed includes:

- **Minimum** — represents the minimum amount of memory that must be available in order to power on the virtual machine
- **Maximum** — represents the amount of memory allocated to the virtual machine when it was configured.
- **Shares** — a value which represents a relative metric for allocating memory to all virtual machines. Symbolic values **low**, **normal**, and **high** are compared to the sum of all shares of all virtual machines on the server and the service console. Share allocation symbolic values can be used to configure their conversion into numeric values.

  For more information on share values, refer to the resource management man pages: `cpu`, `diskbw`, and `mem`.
- **Memory Affinity** — if displayed, this represent the NUMA nodes on the ESX Server system to which the virtual machine can be bound, when the ESX Server system a NUMA system. For information about NUMA systems, see Using Your NUMA System on page 418.

Modifying Memory Values

To modify memory values, click **Edit**. For information on changing memory settings, see Managing Memory Resources from the Management Interface on page 410.

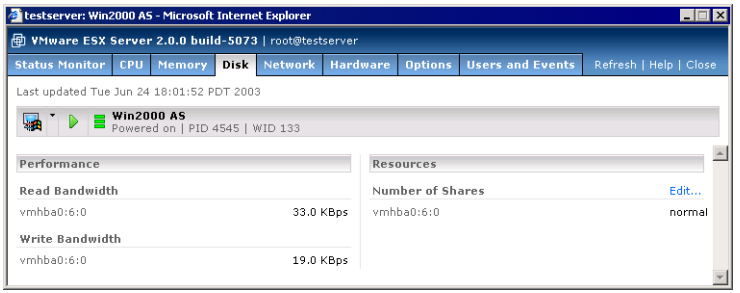
Other activities you can perform when configuring a virtual machine's memory information include:

- Connecting to a Virtual Machine with the VMware Remote Console on page 94
- Using the Virtual Machine Menu on page 95
- Changing the Power State of a Virtual Machine on page 96
- Using Common Controls on page 105

Click the tabs at the top of the page to view more information about the virtual machine.

Configuring a Virtual Machine's Disk Usage

To review and configure the virtual machine's disk settings, click the **Disk** tab. The Disk page appears.



The Disk page shows virtual disk performance information and resources allocated to the virtual disk. Disk bandwidth represents the amount of data that is written to or read from the server's physical disks.

Understanding Performance Values

The values under Performance are based on the past five minutes. The period of time these statistics cover can be modified. See Configuring the Statistics Period for the VMware Management Interface on page 89. Performance information displayed includes:

- **Read Bandwidth** — indicates how much bandwidth is being used when the virtual machine is reading from the physical disk on the server.
- **Write Bandwidth** — indicates how much bandwidth is being used when the virtual machine is writing to the physical disk on the server.

Understanding Resources Values

The values under Resources indicate a range of system memory to which the virtual machine is entitled.

- **Shares** — a value which represents the relative metric for controlling disk bandwidth to all virtual machines. The values **low**, **normal**, and **high** are compared to the sum of all shares of all virtual machines on the server and the service console. Share allocation symbolic values can be used to configure their conversion into numeric values.

  For more information on share values, refer to the resource management man pages: `cpu`, `diskbw`, and `mem`.

- **Memory Affinity** — if displayed, represent the NUMA nodes on the ESX Server system to which the virtual machine can be bound, when the ESX Server system a NUMA system. For information about NUMA systems, see Using Your NUMA System on page 418.

Modifying Disk Values

To modify disk values, click **Edit**. For information on changing disk settings, see Managing Disk Bandwidth on page 432.

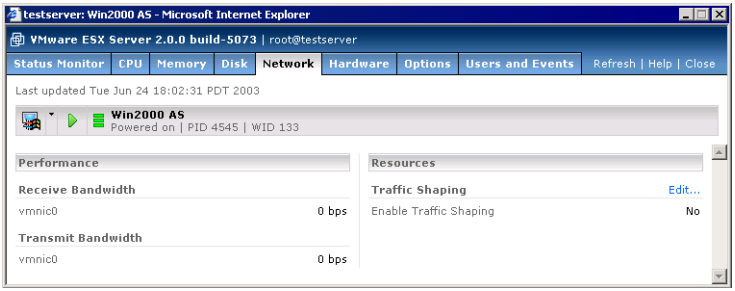
Other activities you can perform when configuring a virtual machine's disk information include:

- Connecting to a Virtual Machine with the VMware Remote Console on page 94
- Using the Virtual Machine Menu on page 95
- Changing the Power State of a Virtual Machine on page 96
- Using Common Controls on page 105

Click the tabs at the top of the page to view more information about the virtual machine.

Configuring a Virtual Machine's Networking Settings

To review and configure the virtual machine's networking settings, click the **Network** tab. The Network page appears.



The Network page shows network performance information and resources allocated to the virtual machine's virtual network card. The receive and transmit bandwidths indicate how fast data is transferred to and from the virtual machine.

The values under Performance are based on the past five minutes. The period of time these statistics cover can be modified. See Configuring the Statistics Period for the VMware Management Interface on page 89.

The Network page also indicates whether traffic shaping is enabled. This setting can be changed.

Activities you can perform when configuring a virtual machine's networking information include:

- Enabling Traffic Shaping on page 115
- Connecting to a Virtual Machine with the VMware Remote Console on page 94
- Using the Virtual Machine Menu on page 95
- Changing the Power State of a Virtual Machine on page 96
- Using Common Controls on page 105

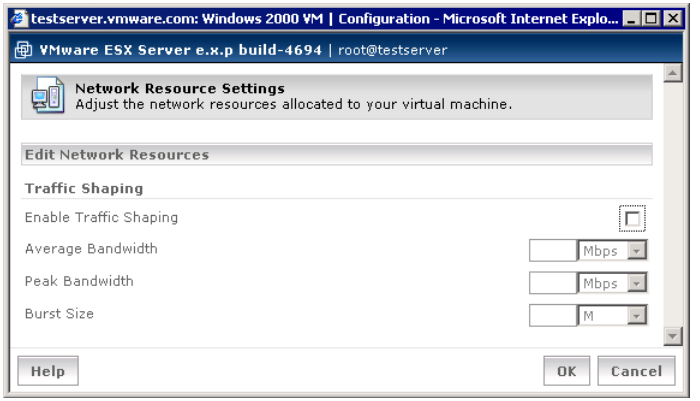
Click the tabs at the top of the page to view more information about the virtual machine.

Enabling Traffic Shaping

When network traffic shaping is enabled, outbound network bandwidth is limited according to the values specified here. Because network traffic is bursty, separate parameters are provided to control both the long-term sustainable Average transmit rate and the short-term Peak transmit rate. The Burst parameter controls the amount of data that may be sent in one burst while exceeding the Average rate. The Peak rate limits the maximum bandwidth during such bursts.

To enable network traffic shaping, complete the following steps.

1. In the Network page, click **Edit**. The Network Resource Settings page appears.



2. To enable traffic shaping, check **Enable Traffic Shaping**, then define network traffic parameters.

3. Specify the average bandwidth. In the **Average Bandwidth** field, specify the average value for network bandwidth, then specify whether that amount is in Megabits per second (**Mbps**), Kilobits per second (**Kbps**) or bits per second (**bps**).
4. Specify the peak bandwidth. In the **Peak Bandwidth** field, specify the peak value for network bandwidth, then specify whether that amount is in Megabits per second (**Mbps**), Kilobits per second (**Kbps**) or bits per second (**bps**).
5. Specify the burst size. In the Burst Size field, specify how large a burst can be, then specify whether that amount is in Megabytes (**M**), Kilobytes (**K**) or bytes (**B**).
6. Click **OK** to save your changes and close the window.

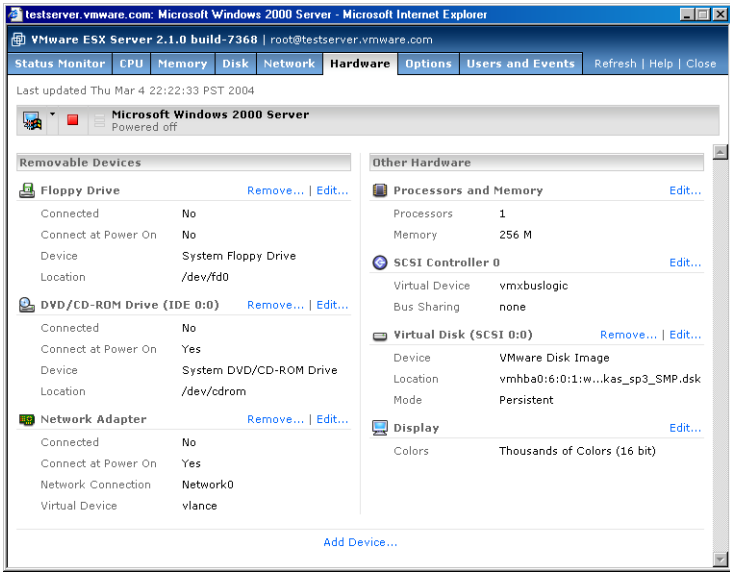
For more information about managing network resources, see Managing Network Bandwidth from the Management Interface on page 428.

Configuring a Virtual Machine's Hardware

To review and configure the virtual hardware inside a virtual machine, click the **Hardware** tab. The Hardware page appears.

The Hardware page lists the virtual hardware in the virtual machine — configured devices like the virtual disk, removable devices like floppy, CD-ROM or DVD-ROM drives, virtual network adapter, memory allocated to the virtual machine and the display settings. More information about each device is listed, and you can configure each virtual hardware component.

Most hardware can be configured only when the virtual machine is powered off.



Activities you can perform when configuring a virtual machine's hardware include:

- Configuring a Virtual Machine's Floppy Drive on page 118
- Configuring a Virtual Machine's DVD-ROM or CD-ROM Drive on page 119
- Configuring a Virtual Machine's Memory and Virtual Processors on page 120
- Configuring a Virtual Machine's Virtual Network Adapters on page 121
- Configuring a Virtual Machine's SCSI Controllers on page 122
- Configuring a Virtual Machine's Virtual Disks on page 123
- Configuring a Virtual Machine's Display Settings on page 126
- Adding a Virtual Disk to a Virtual Machine on page 128
- Adding a Virtual Network Adapter to a Virtual Machine on page 131
- Adding a Virtual DVD/CD-ROM Drive to a Virtual Machine on page 132
- Adding a Virtual Floppy Drive to a Virtual Machine on page 134
- Adding a Generic SCSI Device to a Virtual Machine on page 135
- Adding a Tape Drive to a Virtual Machine on page 136
- Removing Hardware from a Virtual Machine on page 137

- Connecting to a Virtual Machine with the VMware Remote Console on page 94
- Using the Virtual Machine Menu on page 95
- Changing the Power State of a Virtual Machine on page 96
- Using Common Controls on page 105

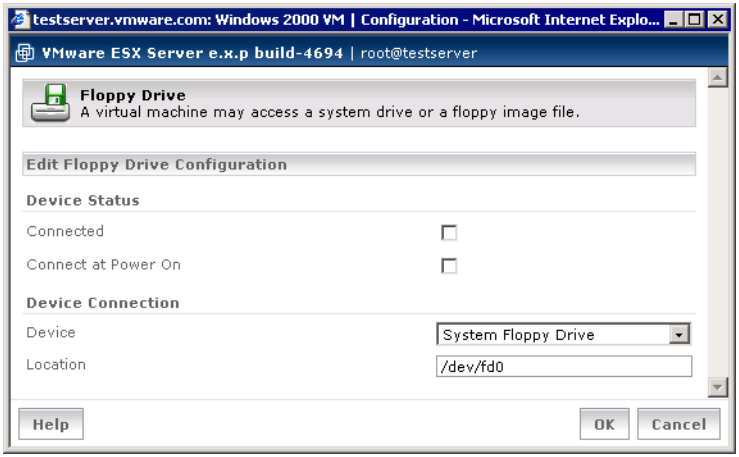
Click the tabs at the top of the page to view more information about the virtual machine.

Configuring a Virtual Machine's Floppy Drive

Each virtual machine can access a physical floppy drive on the server or a floppy image file.

To configure the virtual machine's floppy drive, complete the following steps.

1. In the Hardware page, under **Floppy Drive**, click **Edit**. The Floppy Drive page appears.



2. To connect this virtual machine to the floppy drive, check **Connected**.

   Note: Only one virtual machine can connect to the floppy drive on the server at a time.

3. To connect this virtual machine to the floppy drive when the virtual machine is powered on, check **Connect at Power On**.

4. Specify whether to connect to the server's floppy drive or to a floppy image. In the **Device** list, select **System Floppy Drive** or **Floppy Image**.

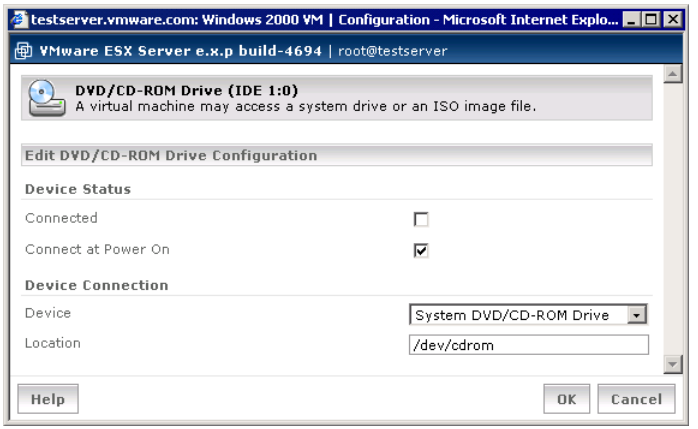
5. Enter the location of the drive or floppy image in the **Location** field. For example, the server's floppy drive could be `/dev/fd0`.
6. Click **OK** to save your changes and close the window.

Configuring a Virtual Machine's DVD-ROM or CD-ROM Drive

Each virtual machine can access a physical DVD-ROM or CD-ROM drive on the server or an ISO image file.

To configure the virtual machine's DVD/CD-ROM drive, complete the following steps.

1. In the Hardware page, under **DVD/CD-ROM Drive**, click **Edit**. The DVD/CD-ROM Drive page appears.



2. To connect this virtual machine to the server's DVD/CD-ROM drive, check **Connected**.

   Note: Only one virtual machine can connect to the DVD/CD-ROM drive on the server at a time.

3. To connect this virtual machine to the server's DVD/CD-ROM drive when the virtual machine is powered on, check **Connect at Power On**.
4. Specify whether to connect to the server's DVD/CD-ROM drive or to an ISO image. In the **Device** list, select **System DVD/CD-ROM Drive** or **ISO Image**.
5. Enter the location of the drive or ISO image in the **Location** field. For example, the server's CD-ROM drive could be `/dev/cdrom`.
6. Click **OK** to save your changes and close the window.

Configuring a Virtual Machine's Memory and Virtual Processors

You can change how much memory to allocate to a virtual machine. You can also review the amount of memory recommended by ESX Server, the maximum amount of memory that can be allocated to the virtual machine and the maximum amount of memory for smooth running of the virtual machine, given the number of virtual processors.

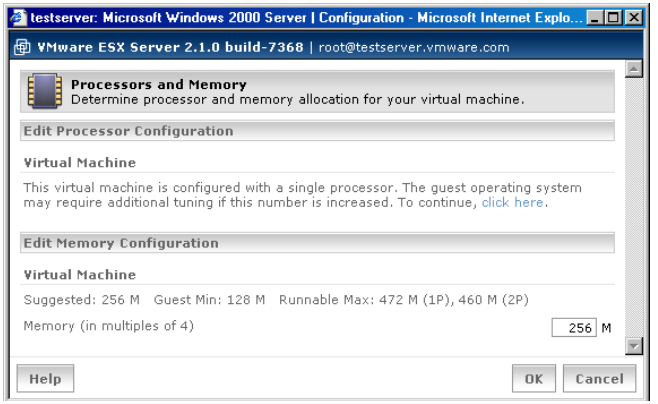
Depending upon the guest operating system in the virtual machine and the number of processors on the server, you can change the number of virtual processors it uses. However, keep in mind the following:

- Virtual machines running certain guest operating systems, such as Windows NT, can be configured with a single processor only. Review the list of supported guest operating systems in the *VMware ESX Server Installation Guide* to see which guests are multiprocessor- or SMP-capable.
- Virtual machines can be configured with multiple processors only if the server has more than one processor. A virtual machine cannot have more virtual processors than the server has physical processors.
- Multiprocessor-capable guest operating systems configured with a single processor may require additional tuning if you increase the number of virtual processors. At most, a virtual machine can have two virtual processors. For more information, see Configuring a Virtual Machine to Use More than One Virtual Processor on page 64.
- Multiprocessor-capable guest operating systems configured and tuned with more than one virtual processor may not boot and will probably degrade the performance of other virtual machines if you change the configuration to a single processor. VMware recommends you do not downgrade a multiprocessor virtual machine to uniprocessor.

Note: You can configure dual-virtual processor virtual machines only if you have purchased the VMware Virtual SMP for ESX Server product. For more information on this product, contact VMware, Inc. or your authorized sales representative.

To configure the virtual machine's virtual processors and memory, complete the following steps.

1. In the Hardware page, under **Processors and Memory**, click **Edit**. The Processors and Memory page appears.


testserver: Microsoft Windows 2000 Server | Configuration - Microsoft Internet Explo...
VMware ESX Server 2.1.0 build-7368 | root@testserver.vmware.com
Processors and Memory
Determine processor and memory allocation for your virtual machine.
Edit Processor Configuration
Virtual Machine
This virtual machine is configured with a single processor. The guest operating system may require additional tuning if this number is increased. To continue, click here.
Edit Memory Configuration
Virtual Machine
Suggested: 256 M Guest Min: 128 M Runnable Max: 472 M (1P), 460 M (2P)
Memory (in multiples of 4)
256 M
Help
OK
Cancel

2. Depending upon the guest operating system and the number of processors with which it is configured, a message appears under Edit Processor Configuration. Provided the guest operating system is multi-processor capable, and if you want to change the number the number of processors, click the **click here** link, then choose the number of virtual processors in the **Processors** list.
3. In the **Memory** field, enter the amount of memory to allocate to the virtual machine. The amount must be a multiple of 4.
4. Click **OK** to save your change and close the window.

Configuring a Virtual Machine's Virtual Network Adapters

You can configure the settings for the virtual machine's virtual network adapter. These settings include the virtual network device to which the virtual machine is bound and the network driver it uses.

To choose the virtual network device, select either the `vmnic` or `vmxnet` adapter. A `vmnic` adapter connects the virtual machine to the physical network adapter, allowing the virtual machine to look and act as another computer on the network. A `vmnet` adapter connects the virtual machine to an internal network of other virtual machines. All the virtual machines on this computer connected to a particular `vmnet` are on the same network.

To choose the network driver for this network connection, you can choose between the `vlance` driver, which installs automatically, and the `vmxnet` driver, which provides better network performance. The difference in network performance is most noticeable if the virtual machine is connected to a Gigabit Ethernet card.

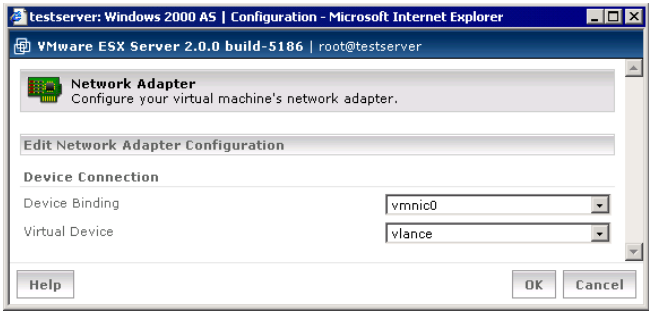
Note: If you use `vmxnet` in a Windows or Linux virtual machine, the virtual network device is not visible to the guest operating system until you install VMware Tools (see Installing VMware Tools in a Linux Guest on page 49).

After the virtual machine is created, you can use this tab to assign additional network adapters to the virtual machine.

If you need help determining which network adapter is associated with a particular device name, you can use the service console's `findnic` command (see The VMkernel Network Card Locator on page 365).

To configure the virtual machine's virtual network adapter, complete the following steps.

1. In the Hardware page, under **Network Adapter**, click **Edit**. The Network Adapter page appears.



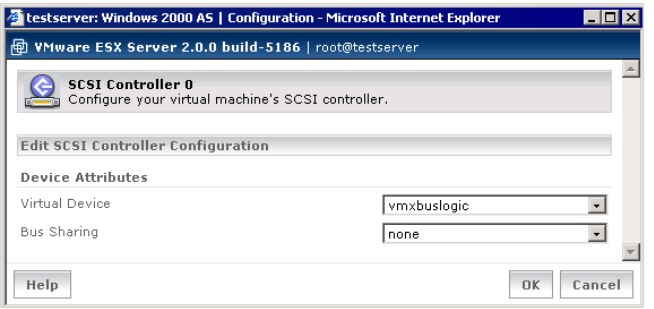
2. In the **Device Binding** list, select the virtual network device which you want the virtual machine to use.
3. In the **Virtual Device** list, select the network driver you want the virtual machine to use. Choose either the `vlance` or `vmxnet` driver.
4. Click **OK** to save your changes and close the window.

Configuring a Virtual Machine's SCSI Controllers

You can configure the settings for the virtual machine's virtual SCSI controller. These settings include the virtual SCSI controller driver and whether the SCSI bus is shared with virtual or physical devices.

To configure the virtual machine's virtual SCSI controller, complete the following steps.

1. In the Hardware page, under **SCSI Controller**, click **Edit**. The SCSI Controller page appears.



2. In the **Virtual Device** list, select the SCSI controller driver which you want the virtual machine to use. Choose `vmxbuslogic` or `vmxlsilogic`.

   Caution: Before you select a different driver, make sure you installed the driver in the guest operating system first; otherwise, the guest cannot boot. To switch to the `vmxlsilogic` driver, see Configuring a Virtual Machine to Use the LSI Logic SCSI Adapter on page 59.

3. In the **Bus Sharing** list, select how you want the virtual machine to share its bus. Choose one of the following:
   - **Physical** — to share disks with virtual machines on any server.
   - **Virtual** — to share disks with virtual machines on the same server.
   - **None** — to prevent sharing of disks with other virtual machines.
4. Click **OK** to save your changes and close the window.

Configuring a Virtual Machine's Virtual Disks

When you configure an existing virtual disk, you can change its disk mode. You can also change the virtual disk a virtual machine uses or create a new virtual disk for the virtual machine.

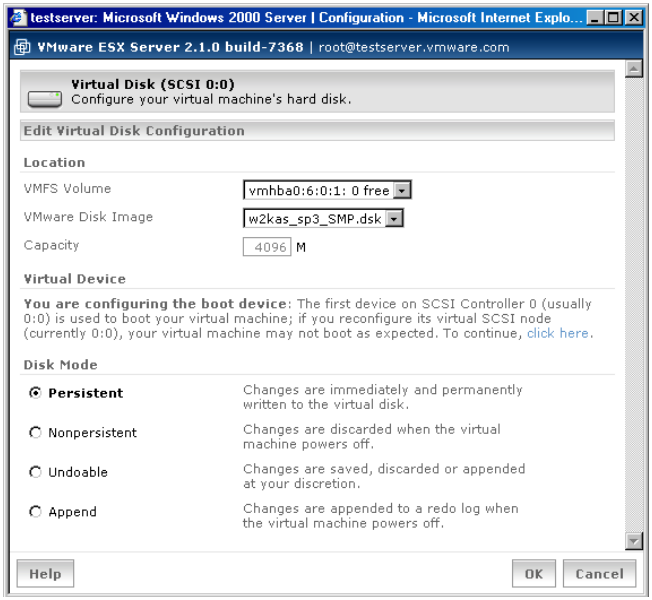
ESX Server can use disks in four different modes.

- **Persistent:** Disks in persistent mode behave exactly like conventional disk drives on a computer. All writes to a disk in persistent mode are written out permanently to the disk as soon as the guest operating system writes the data.
- **Nonpersistent:** All changes to a disk in nonpersistent mode are discarded when a virtual machine session is powered off.

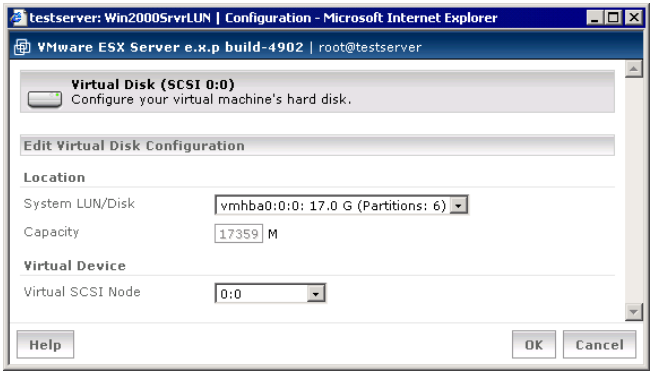
- **Undoable:** When you use undoable mode, you have the option later of keeping or discarding changes you have made during a working session when you power off the virtual machine. Until you decide, the changes are saved in a redo-log file.
- **Append:** Append mode also stores changes in a redo log. It continually adds changes to the redo log until you remove the redo-log file or commit the changes using the `commit` command in `vmkfstools` (see Using vmkfstools on page 229).

To configure the virtual machine's virtual disk, complete the following steps.

1. In the Hardware page, under **Virtual Disk**, click **Edit**. The Virtual Disk page appears.


testserver: Microsoft Windows 2000 Server | Configuration - Microsoft Internet Explo...
VMware ESX Server 2.1.0 build-7368 | root@testserver.vmware.com
Virtual Disk (SCSI 0:0)
Configure your virtual machine's hard disk.
Edit Virtual Disk Configuration
Location
VMFS Volume
vmhba0:6:0:1: 0 free
VMware Disk Image
w2kas_sp3_SMP.dsk
Capacity
4096 M
Virtual Device
You are configuring the boot device: The first device on SCSI Controller 0 (usually 0:0) is used to boot your virtual machine; if you reconfigure its virtual SCSI node (currently 0:0), your virtual machine may not boot as expected. To continue, click here.
Disk Mode
Persistent
Changes are immediately and permanently written to the virtual disk.
Nonpersistent
Changes are discarded when the virtual machine powers off.
Undoable
Changes are saved, discarded or appended at your discretion.
Append
Changes are appended to a redo log when the virtual machine powers off.
Help
OK
Cancel

If the virtual disk is a physical disk on a LUN, the following window appears instead.



2. Do one of the following:

- For an existing virtual disk that is not a physical disk on a LUN, you can change its disk mode. Under **Disk Mode**, click **Persistent**, **Nonpersistent**, **Undoable** or **Append**.
- To select a different virtual disk, do the following.

a. Choose the location of the virtual disk you want to use. In the **VMFS Volume** list, choose the volume on which the virtual disk is located.

b. In the **VMware Disk Image** list, select the virtual disk you want. The size of the virtual disk appears in the **Capacity** field.

c. Choose the disk mode. Under **Disk Mode**, click **Persistent**, **Nonpersistent**, **Undoable** or **Append**.

- To create a new virtual disk for a virtual machine that does not have a physical disk on a LUN, do the following.

a. Choose the location for the new virtual disk. In the **VMFS Volume** list, choose the volume on which to locate the virtual disk. The amount of free space is listed next to the volume name, so you know how large you can make the virtual disk.

b. Give the virtual disk a name. In the **VMware Disk Image** list, select **Other**, then specify the disk name, making sure the file has a `.dsk` extension. Click **OK** to continue creating the disk.

c. Specify the size of the virtual disk. In the **Capacity** field, specify the size of the virtual disk in MB.

d. Choose the disk mode. Under **Disk Mode**, click **Persistent**, **Nonpersistent**, **Undoable** or **Append**.

- If the virtual disk is a physical disk on a LUN, you can do the following.

a. To select a different physical disk on a LUN to use, select it in the **System LUN/ Disk** list.

b. Change the virtual device node. Select the appropriate SCSI ID in the **Virtual SCSI Node** list.

Note: If the virtual disk is on SCSI controller 0:0, a warning appears, stating that changing the SCSI node may cause the virtual machine to boot improperly.

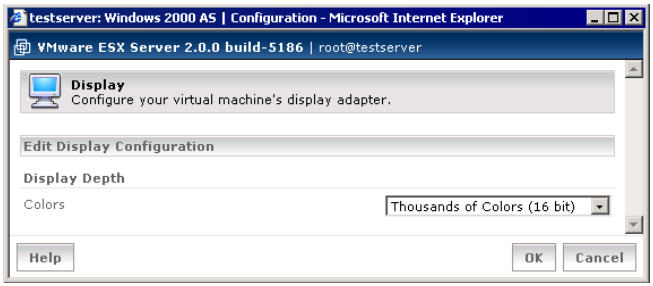
3. **OK** to save your changes and close the window.

Configuring a Virtual Machine's Display Settings

You can configure the display depth or number of colors in a virtual machine. A higher color depth setting slows down screen redraws and increases network load when you use a remote console to view a virtual machine across a network connection. However, with greater color depth, you get better color resolution and fidelity, which may be an issue, depending on the applications you intend to run on the virtual machine.

To configure the virtual machine's display settings, complete the following steps.

1. In the Hardware page, under **Display**, click **Edit**. The Display page appears.

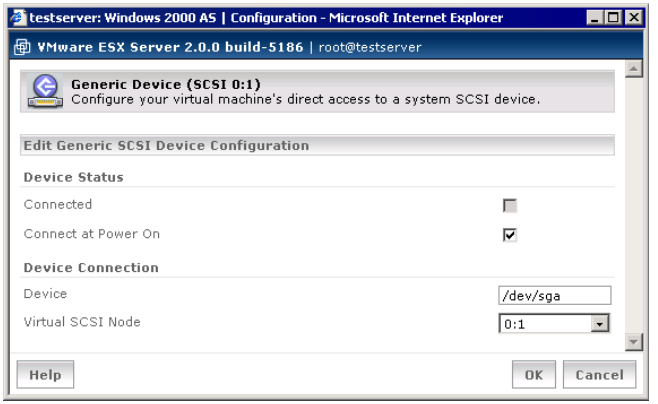


2. In the **Colors** list, select the display depth or the number of colors you want available to the virtual machine. Select **256 Colors (8 bit)**, **Thousands of Colors (15 bit)**, **Thousands of Colors (16 bit)** or **Millions of Colors (24 bit)**.
3. Click **OK** to save your change and close the window.

Configuring a Virtual Machine's Generic SCSI Device

You can configure any generic SCSI devices in a virtual machine. Make sure the virtual machine is powered off, then complete the following steps.

1. To configure an existing generic SCSI device, on the Hardware page, under **Generic SCSI Device**, click **Edit**. The Generic Device (SCSI <ID>) page appears.



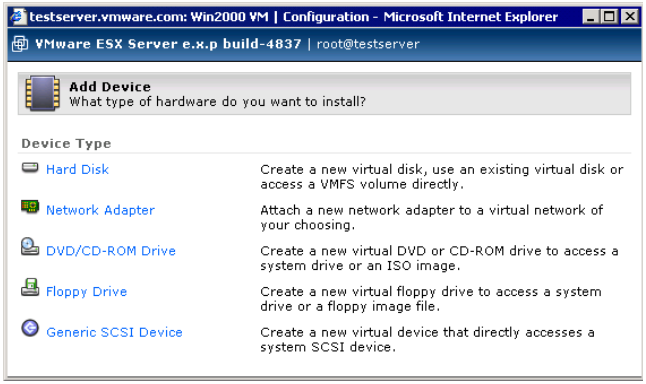
2. To connect this virtual machine to the server's SCSI device when the virtual machine is powered on, check **Connect at Power On**.
3. In the **Device** entry field, specify the name of the device, such as `/dev/sga`.
4. Specify the virtual device node. Select the appropriate SCSI ID in the **Virtual SCSI Node** list.

   Note: If the virtual device is on SCSI controller 0:0, a warning appears, stating that changing the SCSI node may cause the virtual machine to boot improperly.
5. Click **OK** to save your change and close the window.

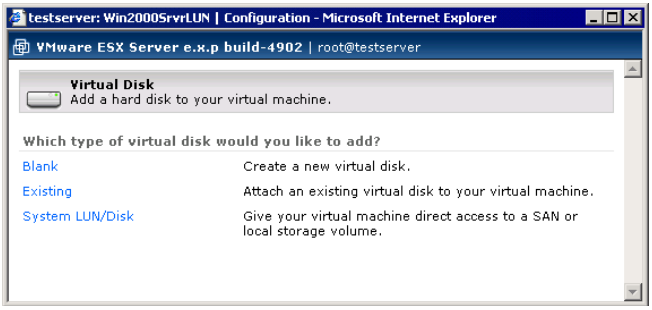
Adding a Virtual Disk to a Virtual Machine

To add a new virtual disk to a virtual machine, make sure the virtual machine is powered off, then complete the following steps.

1. On the Hardware page, click **Add Device**. The Add Device Wizard starts.

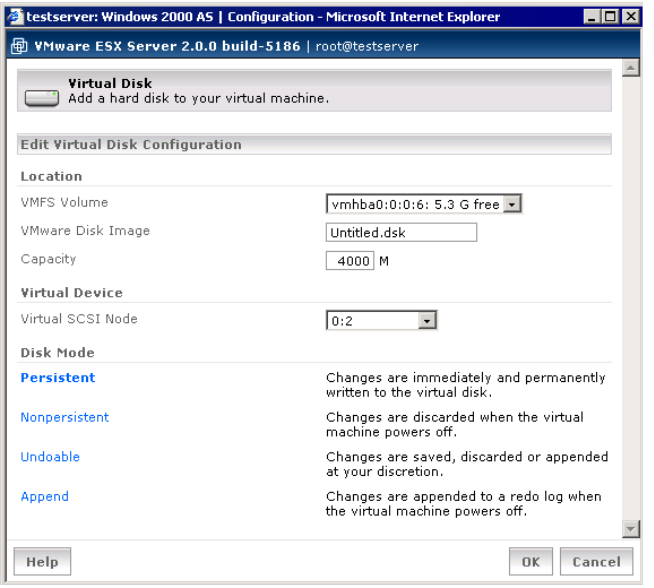

testserver.vmware.com: Win2000 VM | Configuration - Microsoft Internet Explorer
VMware ESX Server e.x.p build-4837 | root@testserver
Add Device
What type of hardware do you want to install?
Device Type
Hard Disk
Create a new virtual disk, use an existing virtual disk or access a VMFS volume directly.
Network Adapter
Attach a new network adapter to a virtual network of your choosing.
DVD/CD-ROM Drive
Create a new virtual DVD or CD-ROM drive to access a system drive or an ISO image.
Floppy Drive
Create a new virtual floppy drive to access a system drive or a floppy image file.
Generic SCSI Device
Create a new virtual device that directly accesses a system SCSI device.

2. Click **Hard Disk**. The Virtual Disk Type page appears.


testserver: Win2000SrvrLUN | Configuration - Microsoft Internet Explorer
VMware ESX Server e.x.p build-4902 | root@testserver
Virtual Disk
Add a hard disk to your virtual machine.
Which type of virtual disk would you like to add?
Blank
Create a new virtual disk.
Existing
Attach an existing virtual disk to your virtual machine.
System LUN/Disk
Give your virtual machine direct access to a SAN or local storage volume.

3. Create one of the following virtual disks:

- Click **Blank** to create a new virtual disk. Then specify the following.



a. Choose the location for the new virtual disk. In the **VMFS Volume** list, choose the volume on which to locate the virtual disk. The amount of free space is listed next to the volume name, so you know how large you can make the virtual disk.

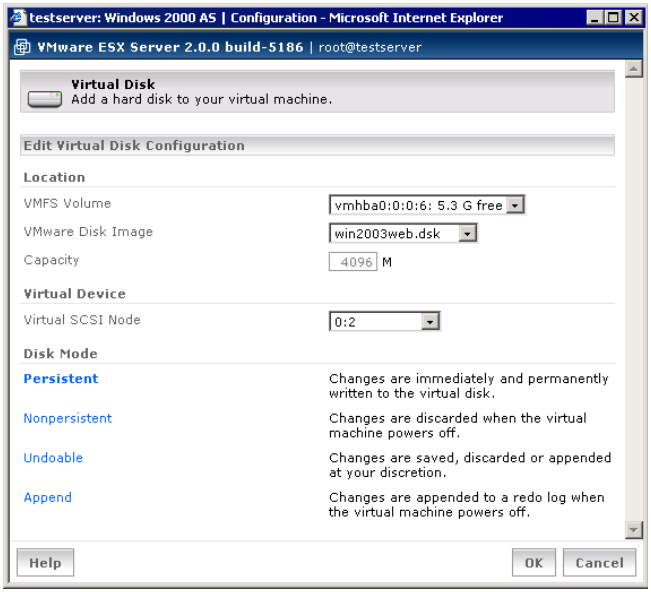
b. Give the virtual disk a name. In the **VMware Disk Image** list, select **Other**, then specify the disk name, making sure the file has a `.dsk` extension. Click **OK** to continue creating the disk.

c. Specify the size of the virtual disk. In the **Capacity** field, specify the size of the virtual disk in MB. The default entry indicates the amount of free space available on the volume.

d. Specify the virtual device node. Select the appropriate SCSI ID in the **Virtual SCSI Node** list.

e. Choose the disk mode. Under **Disk Mode**, click **Persistent**, **Nonpersistent**, **Undoable** or **Append**.

- Click **Existing** to add an existing virtual disk to the virtual machine. Then specify the following.



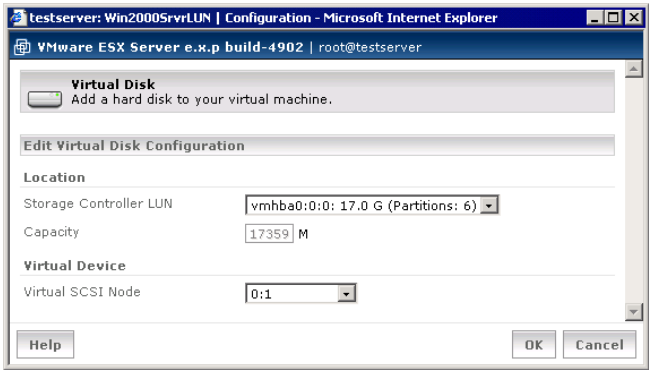
a. Choose the location of the virtual disk you want to use. In the **VMFS Volume** list, choose the volume on which the virtual disk is located.

b. In the **VMware Disk Image** list, select the virtual disk you want. The size of the virtual disk appears in the **Capacity** field.

c. Specify the virtual device node. Select the appropriate SCSI ID in the **Virtual SCSI Node** list.

d. Choose the disk mode. Under **Disk Mode**, click **Persistent**, **Nonpersistent**, **Undoable** or **Append**.

- Click **System LUN/Disk** to allow the virtual machine to access a physical disk stored on a LUN. Then specify the following.



a. Choose the LUN you want to use in the **Storage Controller LUN** list.

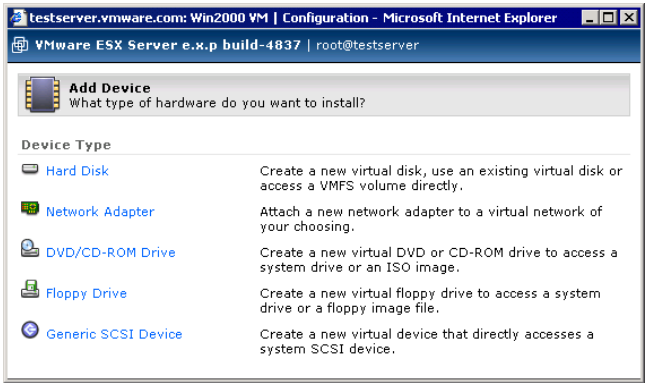
b. Specify the virtual device node. Select the appropriate SCSI ID in the **Virtual SCSI Node** list.

4. Click **OK** to add the disk.

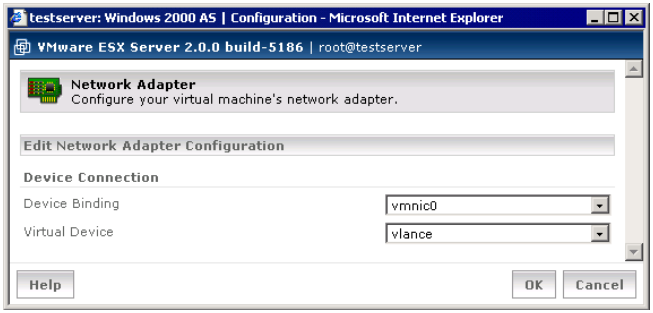
Adding a Virtual Network Adapter to a Virtual Machine

To add a new virtual network adapter to a virtual machine, make sure the virtual machine is powered off, then complete the following steps.

1. On the Hardware page, click **Add Device**. The Add Device Wizard starts.


testserver.vmware.com: Win2000 VM | Configuration - Microsoft Internet Explorer
VMware ESX Server e.x.p build-4837 | root@testserver
Add Device
What type of hardware do you want to install?
Device Type
Hard Disk
Create a new virtual disk, use an existing virtual disk or access a VMFS volume directly.
Network Adapter
Attach a new network adapter to a virtual network of your choosing.
DVD/CD-ROM Drive
Create a new virtual DVD or CD-ROM drive to access a system drive or an ISO image.
Floppy Drive
Create a new virtual floppy drive to access a system drive or a floppy image file.
Generic SCSI Device
Create a new virtual device that directly accesses a system SCSI device.

2. Click **Network Adapter**. The Network Adapter page appears.



3. In the **Device Binding** list, select the virtual network device which you want the virtual machine to use.
4. In the **Virtual Device** list, select the network driver you want the virtual machine to use. Choose either the `vlance` or `vmxnet` driver.
5. Click **OK** to add the network adapter.

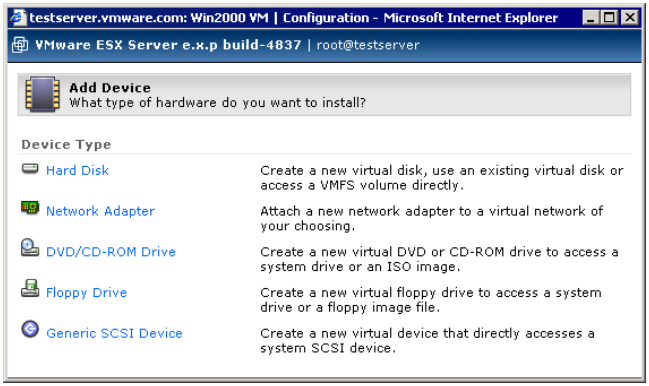
Adding a Virtual DVD/CD-ROM Drive to a Virtual Machine

If your server contains a DVD/CD-ROM drive, you can add a DVD/CD-ROM drive to the virtual machine. You can point the CD-ROM drive to an ISO disk image file.

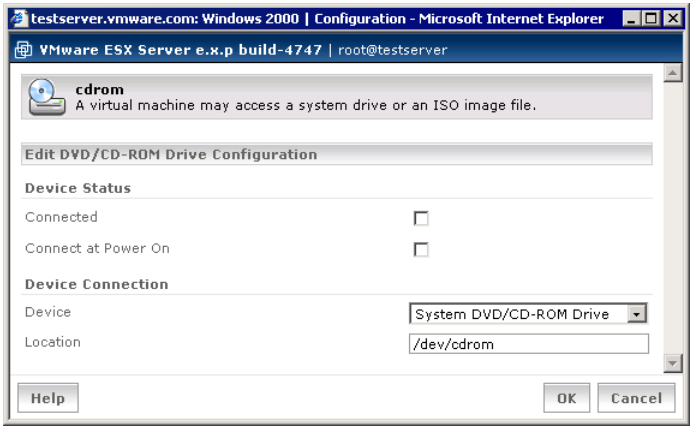
A device can be connected to only one virtual machine on a server at a time.

To add a new virtual DVD/CD-ROM drive to a virtual machine, make sure the virtual machine is powered off, then complete the following steps.

1. On the Hardware page, click **Add Device**. The Add Device Wizard starts.


testserver.vmware.com: Win2000 VM | Configuration - Microsoft Internet Explorer
VMware ESX Server e.x.p build-4837 | root@testserver
Add Device
What type of hardware do you want to install?
Device Type
Hard Disk
Create a new virtual disk, use an existing virtual disk or access a VMFS volume directly.
Network Adapter
Attach a new network adapter to a virtual network of your choosing.
DVD/CD-ROM Drive
Create a new virtual DVD or CD-ROM drive to access a system drive or an ISO image.
Floppy Drive
Create a new virtual floppy drive to access a system drive or a floppy image file.
Generic SCSI Device
Create a new virtual device that directly accesses a system SCSI device.

2. Click **DVD/CD-ROM**. The cdrom page appears.



3. To connect this virtual machine to the server's DVD/CD-ROM drive when the virtual machine is powered on, check **Connect at Power On**.
4. Specify whether to connect to the server's DVD/CD-ROM drive or to an ISO image. In the **Device** list, select **System DVD/CD-ROM Drive** or **ISO Image**.
5. Enter the location of the drive or ISO image in the **Location** field. For example, the server's CD-ROM drive could be `/dev/cdrom`.
6. Click **OK** to add the drive.

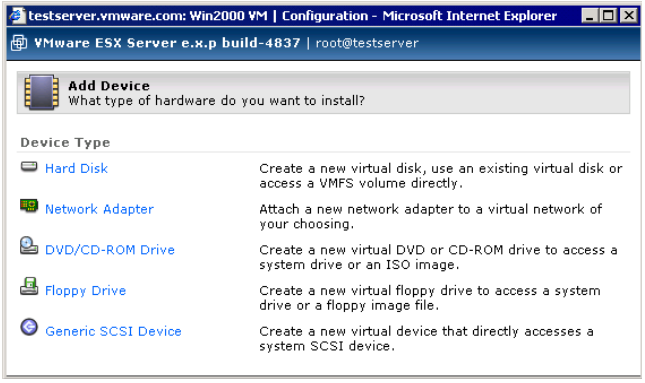
Adding a Virtual Floppy Drive to a Virtual Machine

If your server contains a floppy drive, you can add a virtual floppy drive to the virtual machine. You can point the floppy drive to a floppy disk image file.

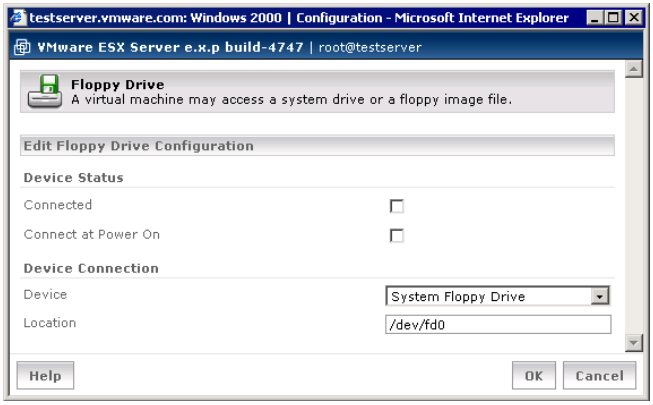
A device can be connected to only one virtual machine on a server at a time.

To add a new virtual floppy drive to a virtual machine, make sure the virtual machine is powered off, then complete the following steps.

1. On the Hardware page, click **Add Device**. The Add Device Wizard starts.


testserver.vmware.com: Win2000 VM | Configuration - Microsoft Internet Explorer
VMware ESX Server e.x.p build-4837 | root@testserver
Add Device
What type of hardware do you want to install?
Device Type
Hard Disk
Create a new virtual disk, use an existing virtual disk or access a VMFS volume directly.
Network Adapter
Attach a new network adapter to a virtual network of your choosing.
DVD/CD-ROM Drive
Create a new virtual DVD or CD-ROM drive to access a system drive or an ISO image.
Floppy Drive
Create a new virtual floppy drive to access a system drive or a floppy image file.
Generic SCSI Device
Create a new virtual device that directly accesses a system SCSI device.

2. Click **Floppy Drive**. The Floppy Drive page appears.



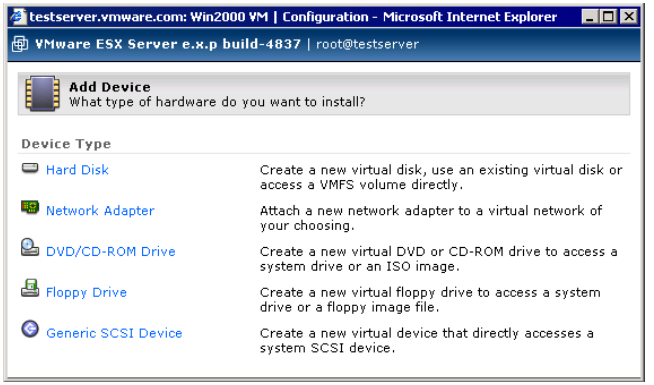
3. To have the floppy drive be connected to the virtual machine when you power it on, check **Connect at Power On**.
4. Specify whether to connect to the server's floppy drive or to a floppy image. In the **Device** list, select **System Floppy Drive** or **Floppy Image**.

5. Enter the location of the drive or floppy image in the **Location** field. For example, the server's floppy drive could be `/dev/fd0`.
6. Click **OK** to add the drive.

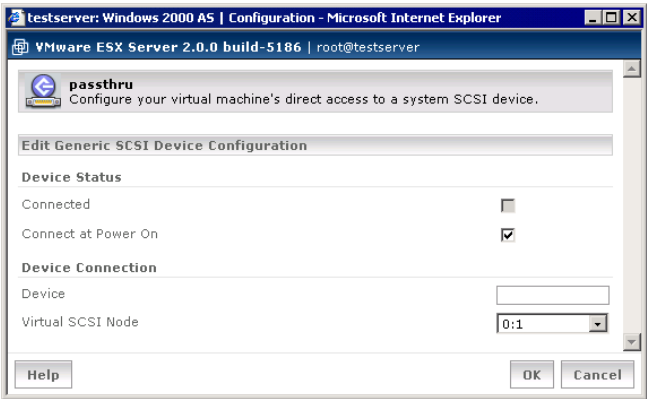
Adding a Generic SCSI Device to a Virtual Machine

To add a new generic SCSI device to a virtual machine, make sure the virtual machine is powered off, then complete the following steps.

1. On the Hardware page, click **Add Device**. The Add Device Wizard starts.


testserver.vmware.com: Win2000 VM | Configuration - Microsoft Internet Explorer
VMware ESX Server e.x.p build-4837 | root@testserver
Add Device
What type of hardware do you want to install?
Device Type
Hard Disk
Create a new virtual disk, use an existing virtual disk or access a VMFS volume directly.
Network Adapter
Attach a new network adapter to a virtual network of your choosing.
DVD/CD-ROM Drive
Create a new virtual DVD or CD-ROM drive to access a system drive or an ISO image.
Floppy Drive
Create a new virtual floppy drive to access a system drive or a floppy image file.
Generic SCSI Device
Create a new virtual device that directly accesses a system SCSI device.

2. Click **Generic SCSI Device**. The SCSI Device page appears.



3. To connect this virtual machine to the server's SCSI device when the virtual machine is powered on, check **Connect at Power On**.
4. In the **Device** entry field, specify the name of the device, such as `/dev/sga`.

5. Specify the virtual device node. Select the appropriate SCSI ID in the **Virtual SCSI Node** list.
6. Click **OK** to add the device.

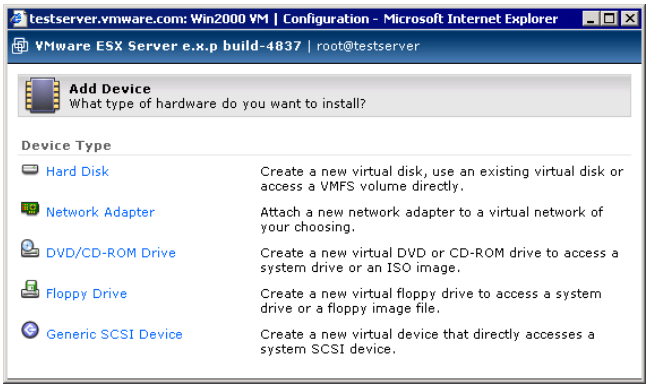
Adding a Tape Drive to a Virtual Machine

To add a new tape drive to a virtual machine, make sure the virtual machine is powered off, then complete the following steps.

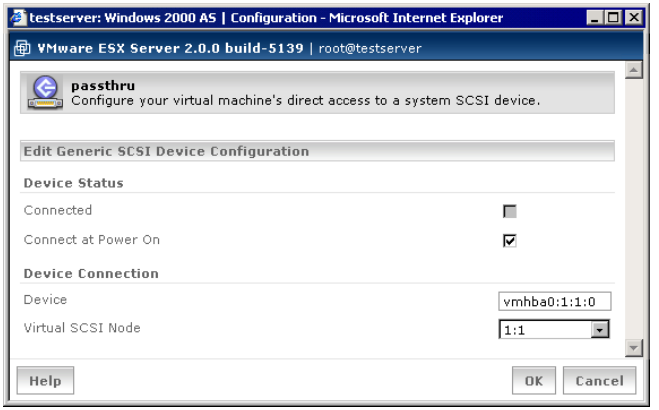
1. Check the SCSI ID of the controller for the tape drive seen by ESX Server, by logging into the service console and viewing the output of the various files `/proc/vmware/scsi/vmhba<x>/<y>:<z>`, where `<x>` is the HBA ID assigned by ESX Server, `<y>` is the SCSI target ID, and `<z>` is the SCSI LUN ID.

   The tape drive should be described in the top portion of one of these files. Note the values of `<x>`, `<y>` and `<z>` that correspond to the file with the tape drive in it.

2. On the Hardware page, click **Add Device**. The Add Device Wizard starts.


testserver.vmware.com: Win2000 VM | Configuration - Microsoft Internet Explorer
VMware ESX Server e.x.p build-4837 | root@testserver
Add Device
What type of hardware do you want to install?
Device Type
Hard Disk
Create a new virtual disk, use an existing virtual disk or access a VMFS volume directly.
Network Adapter
Attach a new network adapter to a virtual network of your choosing.
DVD/CD-ROM Drive
Create a new virtual DVD or CD-ROM drive to access a system drive or an ISO image.
Floppy Drive
Create a new virtual floppy drive to access a system drive or a floppy image file.
Generic SCSI Device
Create a new virtual device that directly accesses a system SCSI device.

3. Click **Generic SCSI Device**. The SCSI Device page appears.



4. To connect this virtual machine to the server's SCSI device when the virtual machine is powered on, check **Connect at Power On**.
5. In the **Virtual SCSI Node** field, select `<x>:<y>` as determined in step 1.
6. In the **Device** entry field, type:

   `vmhba<x>:<y>:<z>:0`
7. Click **OK** to add the device.

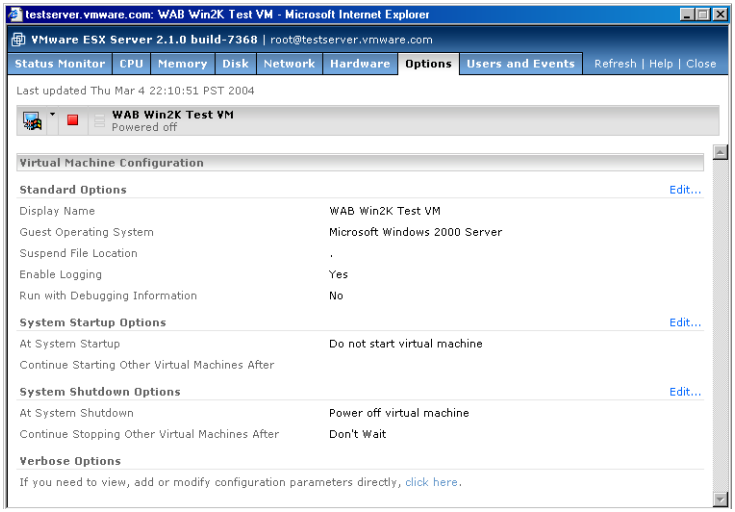
Removing Hardware from a Virtual Machine

To remove hardware from a virtual machine, access the Hardware page. Next to the item you want to remove, click **Remove**. You are asked for confirmation before the device is removed.

Note: You cannot remove some items from a virtual machine, such as the processor, SCSI controller or the virtual display.

Setting Standard Virtual Machine Configuration Options

To review and modify basic information about a virtual machine, or to access the configuration file directly, click the **Options** tab. The Options page appears.



The Options page shows standard virtual machine information:

- **Display Name** — identifies the virtual machine in a more descriptive way.
- **Guest Operating System** — the guest operating system installed on the virtual disk.
- **Suspend File Location** — the location of the suspended state file (a VMFS volume); this file is created when you suspend a virtual machine and contains the information about the virtual machine's state at the time at which it was suspended. ESX Server automatically adds a suffix to the name of the suspended state file to ensure that one virtual machine does not overwrite the suspended state file of another.

  Note: Unlike earlier versions of ESX Server, the suspended state file can only reside on a VMFS volume; it cannot be located in the directory with the virtual machine's configuration file in the service console.
- **Enable Logging** — whether logging is enabled.
- **Run with Debugging Information** — whether the virtual machine is running with debugging information, which is useful to have enabled when you are experiencing problems with this virtual machine, as you can provide this

information to VMware support to help troubleshoot any problems you are experiencing.

- System Startup Options — the startup options for this virtual machine when the server starts.
- System Shutdown Options — the shutdown options for this virtual machine when the server shuts down.

  To change the startup and shutdown options, see Setting Startup and Shutdown Options for a Virtual Machine on page 25. To change any other options, see Changing Standard Virtual Machine Configuration Options on page 26.

  Under Verbose Options, you can enter and modify configuration file entries by hand. See Modifying the Configuration File Directly (Advanced Users Only) on page 141.

Setting Startup and Shutdown Options for a Virtual Machine

You can configure what a virtual machine does when the system starts and how it shuts down when the system shuts down. You can enable these settings only if the startup and shutdown options are enabled for the server overall. See Configuring Startup and Shutdown Options for Virtual Machines on page 257.

Startup Options

The virtual machine startup options include:

- At System Startup — whether or not this virtual machine should start when the server starts. By default, virtual machines do not start automatically when the system starts up.
- Continue Starting Other Virtual Machines After — the amount of time to wait after starting the virtual machine before starting another virtual machine. Settings for starting virtual machines include: the system default, do not wait to start, wait for a certain number of minutes to start or start when VMware Tools starts.

Shutdown Options

The virtual machine startup options include:

- At System Shutdown, Attempt to — sets the shutdown action for the virtual machine when the server is shut down. At system shutdown, settings for shutting down virtual machines include: power off the virtual machine, shut down the guest operating system or suspend the virtual machine. By default, all virtual machines are powered off when the system shuts down.

- **Continue Stopping Other Virtual Machines After** — the amount of time to wait after stopping the virtual machine before stopping another virtual machine. Settings for stopping virtual machines include: the system default, no wait or wait for a certain number of minutes.

Configuring a Virtual Machine's Startup and Shutdown Options

Complete the following steps.

1. Power off the virtual machine and click **Edit** under System Startup Options or System Shutdown Options. The Options page appears.
2. To allow the virtual machine to start up when the system starts up, check the **Start Virtual Machine** check box.
3. Specify the period of time before the next virtual machine starts, in the Continue Starting Virtual Machines After list, choose the number of minutes or whether ESX Server should not wait before starting the next virtual machine. If you select Other, specify the number of minutes to wait in the prompt that appears.

   To specify that VMware Tools should start in a virtual machine before the next virtual machine starts, check the when VMware Tools starts check box. If VMware Tools does not start in the virtual machine before the time specified previously elapses, ESX Server starts the next virtual machine.

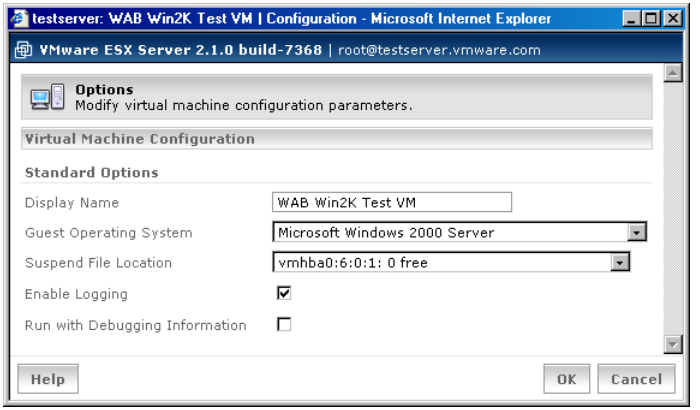
   Specify what happens to the virtual machine when the system shuts down. In the At System Shutdown, Attempt to list, select whether you want to power off the virtual machine, shut down the guest operating system or suspend the virtual machine.

   To configure when ESX Server should stop the next virtual machine after this virtual machine stops, in the Continue Stopping Other Virtual Machines After list, choose the number of minutes or whether ESX Server should not wait before starting the next virtual machine. If you want to choose a number of minutes other than what is displayed in the list, select Other and enter the number of minutes at the prompt.
4. Click **OK** to save your settings.
5. Click **Close Window** to return to the virtual machine's Options page.

Changing Configuration Options

To change any of these options:

1. Power off the virtual machine and click **Edit**. The Options Configuration page appears.



Note: You can change the display name when the virtual machine is powered on.

2. Make your changes, then click **OK** to save them.
3. Close the window.

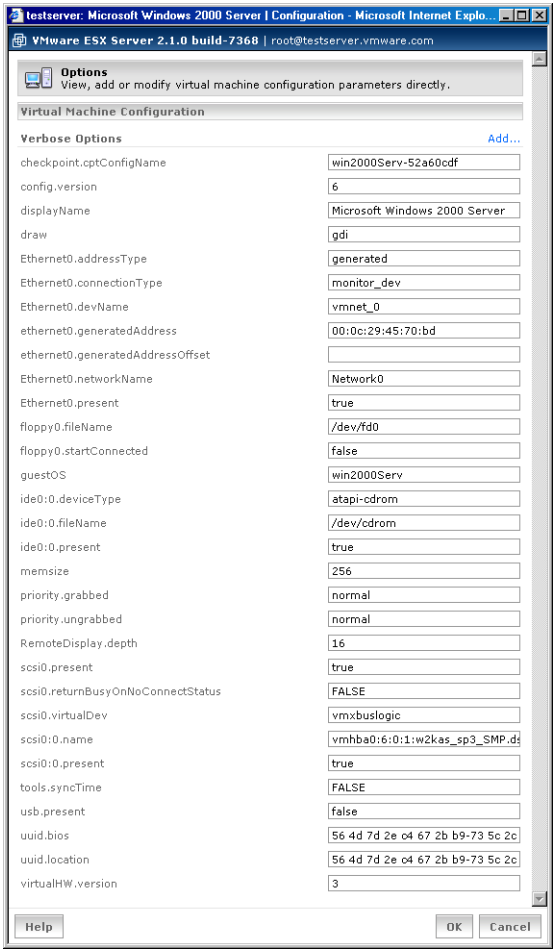
Modifying the Configuration File Directly (Advanced Users Only)

If you need to add or change a configuration option for a virtual machine that cannot be accessed from elsewhere in the management interface, you can edit the virtual machine's configuration file (the file with the `.vmx` extension) from the Options tab. For example, if you want to enable repeatable resume in the virtual machine, you would add the option to the configuration file in the manner described below.

Caution: You should not add or change any options in your configuration file unless you have been given a specific option to add to the file in another part of the user documentation or if you are working with VMware support to solve an issue with your virtual machine.

To add an option to the configuration file (`.vmx`), make sure you are logged into the management interface as the virtual machine user or a user with the proper permissions to modify this virtual machine (such as the root user), then complete the following steps.

1. Under Verbose Options, click the link. The Options window appears.



2. Click **Add**.
3. A prompt appears. Enter a name for the option, then click **OK**.

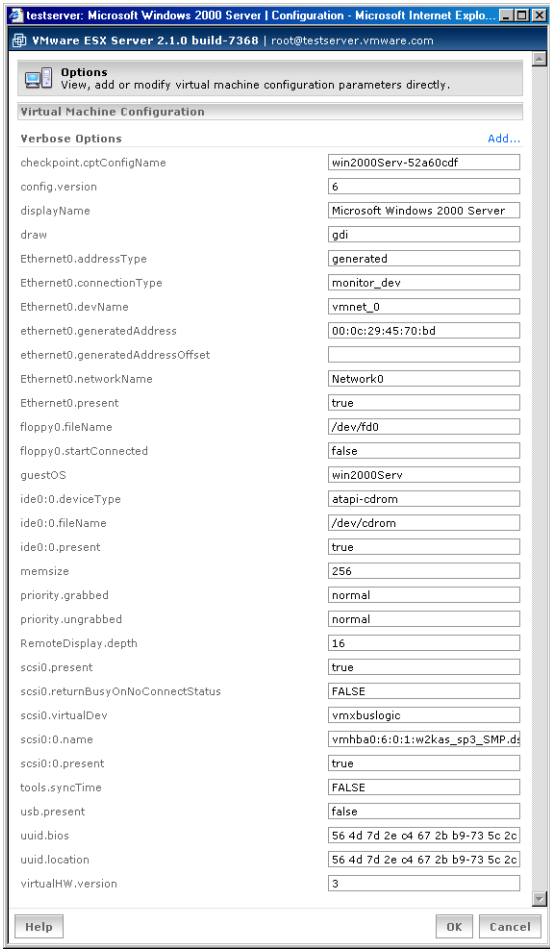
   For example, if you want to enable repeatable resume in the virtual machine, create an option called `resume.repeatable`.
4. Another prompt appears. Enter a value for option you specified, then click **OK**.

   For example, set the value of `resume.repeatable` to `TRUE`.

5. Click **OK** in the Options window to save the change to the configuration file.

To change an option in the configuration file (`.vmx`), complete the following steps.

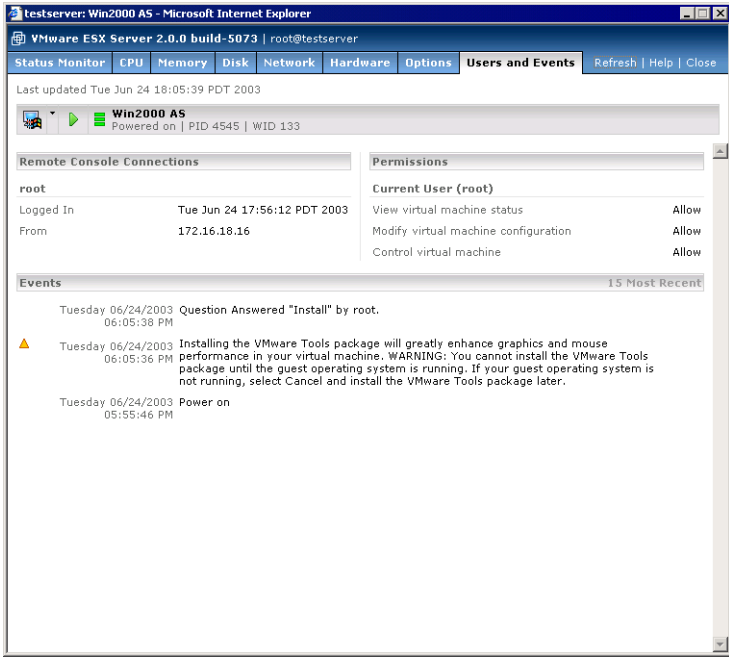
1. Under Verbose Options, click the link. The Options window appears.



2. Locate the option, then change the value for the option in the entry field to the right of the option.
3. Click **OK** to save your change and close the Options window.

Viewing a List of Connected Users

To see a list of users that are connected to a virtual machine with a remote console, click the **Users and Events** tab. The Users and Events page appears.


testserver: Win2000 AS - Microsoft Internet Explorer
VMware ESX Server 2.0.0 build-5073 | root@testserver
Status Monitor
CPU
Memory
Disk
Network
Hardware
Options
Users and Events
Refresh | Help | Close
Last updated Tue Jun 24 18:05:39 PDT 2003
Win2000 AS
Powered on | PID 4545 | WID 133
Remote Console Connections
root
Logged In
Tue Jun 24 17:56:12 PDT 2003
From
172.16.18.16
Permissions
Current User (root)
View virtual machine status
Allow
Modify virtual machine configuration
Allow
Control virtual machine
Allow
Events
15 Most Recent
Tuesday 06/24/2003 06:05:38 PM
Question Answered "Install" by root.
Tuesday 06/24/2003 06:05:36 PM
Installing the VMware Tools package will greatly enhance graphics and mouse performance in your virtual machine. WARNING: You cannot install the VMware Tools package until the guest operating system is running. If your guest operating system is not running, select Cancel and install the VMware Tools package later.
Tuesday 06/24/2003 05:55:46 PM
Power on

The list under **Remote Console Connections** identifies any users connected to the virtual machine with a remote console. The list includes the time and IP address from which the user connected to the virtual machine.

The list under **Permissions** indicates what you can do with the virtual machine. You are either allowed or denied the following abilities:

- Viewing virtual machine status.
- Modifying the virtual machine's configuration.
- Controlling the virtual machine: powering it on or off, suspending or resuming it.

Activities you can perform when viewing a virtual machine's user and event information include:

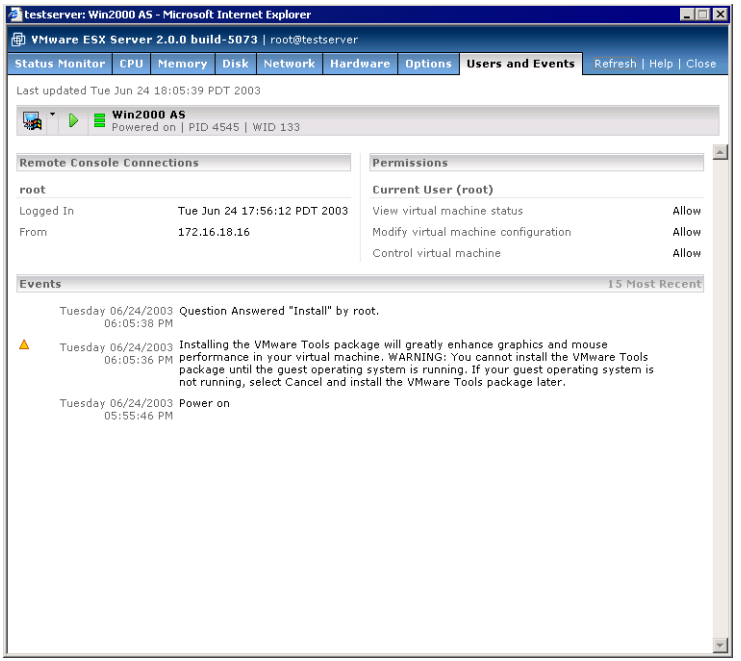
- Connecting to a Virtual Machine with the VMware Remote Console on page 94
- Using the Virtual Machine Menu on page 95

- Changing the Power State of a Virtual Machine on page 96
- Using Common Controls on page 105

Click the tabs at the top of the page to view more information about the virtual machine.

Viewing a Log of a Virtual Machine's Events

A log of the 15 most recent virtual machine events is available. Click the **Users and Events** tab. The Users and Events page appears.


testserver: Win2000 AS - Microsoft Internet Explorer
VMware ESX Server 2.0.0 build-5073 | root@testserver
Status Monitor
CPU
Memory
Disk
Network
Hardware
Options
Users and Events
Refresh | Help | Close
Last updated Tue Jun 24 18:05:39 PDT 2003
Win2000 AS
Powered on | PID 4545 | WID 133
Remote Console Connections
root
Logged In
Tue Jun 24 17:56:12 PDT 2003
From
172.16.18.16
Permissions
Current User (root)
View virtual machine status
Allow
Modify virtual machine configuration
Allow
Control virtual machine
Allow
Events
15 Most Recent
Tuesday 06/24/2003 06:05:38 PM
Question Answered "Install" by root.
Tuesday 06/24/2003 06:05:36 PM
Installing the VMware Tools package will greatly enhance graphics and mouse performance in your virtual machine. WARNING: You cannot install the VMware Tools package until the guest operating system is running. If your guest operating system is not running, select Cancel and install the VMware Tools package later.
Tuesday 06/24/2003 05:55:46 PM
Power on

The **Events** list displays a log of the most recent actions or events recorded in the virtual machine, such as the questions VMware ESX Server asks, errors and other events like the powering on or off of the virtual machine. The events appear in reverse chronological order.

The event log draws its data from the log file for the virtual machine's configuration file stored, by default, in the virtual machine's directory, `<homedir>/vmware/<guestOS>`.

When you perform an action within the management interface that prompts the virtual machine to generate a message needing your response before it can proceed, a waiting for input message appears in the **Display Name** column. When you click that link, a popup window appears, prompting you for a response. After you provide your answer, the popup window closes.

The log shows the date and time the event occurred and an explanation of the event. Some events have a symbol associated with them that corresponds to the type of event that occurred.

- This type of event indicates a question or a warning was generated by the virtual machine.

- This type of event indicates an error occurred in the virtual machine.

Click the tabs at the top of the page to view more information about the virtual machine.

Modifying Virtual Machine Peripherals

A virtual machine's peripheral devices can be viewed and modified through the management interface. This section provides an overview of the configuration modification options.

The changes you can make include:

- Adding More than Six SCSI Virtual Disks to a Virtual Machine on page 147
- Using a Physical (Raw) Disk in a Virtual Machine on page 148
- Using Parallel Ports in a Virtual Machine on page 149
- Using Serial Ports in a Virtual Machine on page 150
- Using Disk Modes on page 151

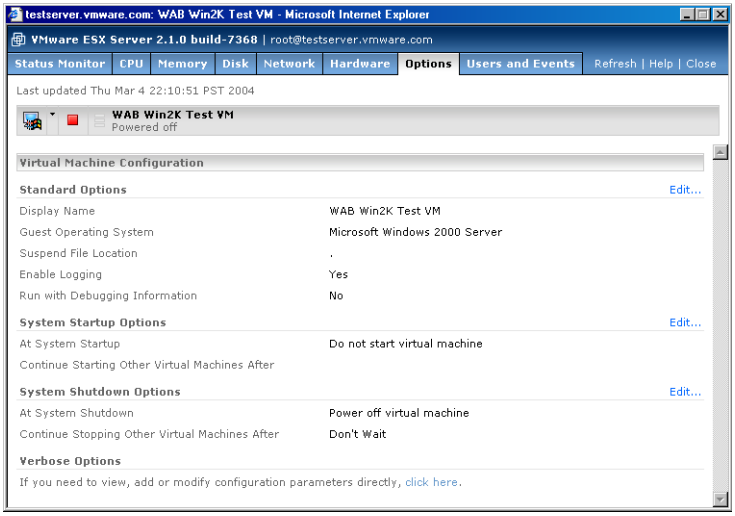
Caution: These procedures involve modifying a virtual machine's configuration file settings directly. Only advanced users should do this. Consider backing up the configuration file (`.vmx`) before making changes.

Adding More than Six SCSI Virtual Disks to a Virtual Machine

You can add up to six virtual SCSI disks on a single SCSI controller to a virtual machine using the VMware Management Interface. To do so, log in to the management interface as a user with the permissions to configure the virtual machine, click the link to the virtual machine's name, then click **Hardware** next to Configuration in the virtual machine summary. Click **Add Device**, and follow the wizard to add a new **Hard Disk**.

To add more than six disks to the same controller (up to eight more), you must edit the virtual machine's configuration file directly. Device ID 7 is used by the SCSI controller, so you cannot use that ID for a virtual disk. For each disk you want to add from ID 8 through ID 15, take the following steps.

1. On the Options tab for the virtual machine, click the link under Verbose Options.



2. Click **Add**. Create an option called `scsi0:8.present` and set its value to `true`.
3. Click **Add**. Create an option called `scsi0:8.name` and set its value to `<vmfsname>:<diskfilename>.dsk`.

   In these entries, `scsi0` refers to the first SCSI controller and `8` is the device ID.
4. Click **OK** to save your changes and close the configuration file.

By default, the virtual disk is created in persistent mode. To change the disk mode, click the **Hardware** tab. Edit the disk as described in Configuring a Virtual Machine's Virtual Disks on page 123.

Using a Physical (Raw) Disk in a Virtual Machine

In some configurations, you may want to give a virtual machine direct access to a physical disk partition stored on a LUN, rather than using a virtual disk stored as a file on a VMFS. This can be useful, for example, if the virtual machine needs shared access to data stored on a physical disk.

In order for the virtual machine to access a physical disk, add a new virtual disk as described in Adding a Virtual Disk to a Virtual Machine on page 128 and be sure to click **System LUN/Disk**.

Using Parallel Ports in a Virtual Machine

To connect the virtual machine's first parallel port (LPT1) to the physical computer's first parallel port, take the following steps:

1. Reboot the physical computer and enter the BIOS setup. Typically, you do so by pressing F2 or Delete while the machine is booting. Find the parallel port mode setting and set it to PS/2. (The typical choices are AT and PS/2.) If PS/2 is not available as an option, set it to bidirectional.
2. Log on to the console operating system as root and enter the following commands:

   ```
   /sbin/insmod parport
   /sbin/insmod parport_pc
   /sbin/insmod ppdev
   ```

   Type `lsmod` and confirm that these modules are in the listing of loaded modules.

   To make these changes permanent, add the three lines shown above to the end of the file `/etc/rc.d/rc.local`.
3. Be sure the virtual machine is shut down and powered off, then add the following options to the virtual machine's configuration file as described in Modifying the Configuration File Directly (Advanced Users Only) on page 141.
   - Add an option called `parallel0.present` and set its value to `true`.
   - Add an option called `parallel0.fileName` and set its value to `"/dev/parport0"`.
   - Add an option called `parallel0.bidirectional` and set its value to `true`.
4. Be sure the virtual machine is using virtual hardware version 6. Look for the following line in the configuration file:

   ```
   config.version = 6
   ```

   This line should already be present in the configuration file for any virtual machine created with ESX Server 1.5.x. or ESX Server 2.1. If the virtual machine was created under ESX Server 1.0 or 1.1 and has not already been updated, add the `config.version = 6` line to the configuration file.

   Note: When the virtual machine starts after you update the virtual hardware version, you see a dialog box with the message "The CMOS of this virtual machine is incompatible with the current version of VMware ESX Server. A new CMOS with default values will be used instead." Click **OK**. As the virtual machine

starts, the guest operating system may detect new virtual hardware and install drivers for it. Respond to any messages as you would if upgrading the hardware on a physical computer.

5. Start the virtual machine using the remote console. As it starts to boot, click inside the remote console window, then press F2 to enter the virtual machine's BIOS setup. Go to the Advanced I/O Device Configuration section and configure the parallel port mode for the virtual machine to bidirectional.

Now your virtual machine can use a dongle or other parallel port device.

Note: As you start the virtual machine, you may see a message warning that the parallel port is starting disconnected. If you do, connect to the virtual machine with a remote console and use the remote console's Devices menu to connect the parallel port.

Note: Only one operating system can be connected to the parallel port at one time. You cannot configure more than one virtual machine to use a particular parallel port at a given time.

Using Serial Ports in a Virtual Machine

To connect the virtual machine's first serial port (COM1) to the physical computer's first serial port, edit the virtual machine's configuration directly using the VMware Management Interface.

Be sure the virtual machine is shut down and powered off, then add the following lines to the configuration file as described in Modifying the Configuration File Directly (Advanced Users Only) on page 141.

- Add an option called `serial0.present` and set its value to `true`.
- Add an option called `serial0.fileType` and set its value to `device`.
- Add an option called `serial0.fileName` and set its value to `/dev/ttyS0`.

When you power on the virtual machine, you can configure the serial port in the guest operating system.

When the virtual machine is running, you can use the **Devices** menu on the remote console to connect and disconnect its serial port.

You may also control whether the virtual machine starts with its serial port connected to the physical computer's serial port. To set the first serial port so it is connected when the virtual machine starts, add an option to the configuration file called `serial0.startConnected` and set its value to `true`, as described in Modifying the Configuration File Directly (Advanced Users Only) on page 141.

To reconfigure the virtual machine so it starts with the first serial port disconnected, either change the value for the `serial0.startConnected` option to `false`.

Note: Only one operating system can be connected to the serial port at one time. You cannot configure more than one virtual machine to use a particular serial port at a given time. To use additional serial ports, use a higher number in the lines you add to the configuration file.

Changing the number after `serial` affects the serial port that is available inside the virtual machine. Changing the number after `/dev/ttyS` affects the port that is used on your physical computer. For example, to connect the virtual machine's second serial port (COM2) to the physical computer's second serial port, add the following lines to the configuration file as described in Modifying the Configuration File Directly (Advanced Users Only) on page 141.

- Add an option called `serial1.present` and set its value to `true`.
- Add an option called `serial1.fileType` and set its value to `device`.
- Add an option called `serial1.fileName` and set its value to `/dev/ttyS1`.

Using Disk Modes

ESX Server can use disks in four different modes: persistent, nonpersistent, undoable and append.

- **Persistent:** Persistent disks behave exactly like conventional disk drives on a computer. All writes to a persistent disk are written out permanently to the disk as soon as the guest operating system writes the data.
- **Nonpersistent:** All changes to a nonpersistent mode disk are discarded after the virtual machine is powered off.
- **Undoable:** When you use undoable mode, you have the option later of keeping or discarding changes you have made during a working session. Until you decide, the changes are saved in a redo-log file. When you power off the virtual machine, you are prompted to commit the changes, keep the log by continuing to save changes to the redo log or discard the changes.
- **Append:** VMware ESX Server supports an additional append mode for virtual disks stored as VMFS files. Like undoable mode, append mode maintains a redo log. However, in this mode, no dialog appears when the virtual machine is powered off to ask whether you want to commit changes. All changes are continually appended to the redo log. At any point, the changes can be undone by removing the redo log. You should shut down the guest operating system and power off the virtual machine before deleting that virtual machine's redo

log. You can also commit the changes to the main virtual disk file using the `commit` option in `vmkfstools`. See Using vmkfstools on page 229 for details.

To change the disk mode for a virtual disk, see Configuring a Virtual Machine's Virtual Disks on page 123.

Deleting a Virtual Machine Using the VMware Management Interface

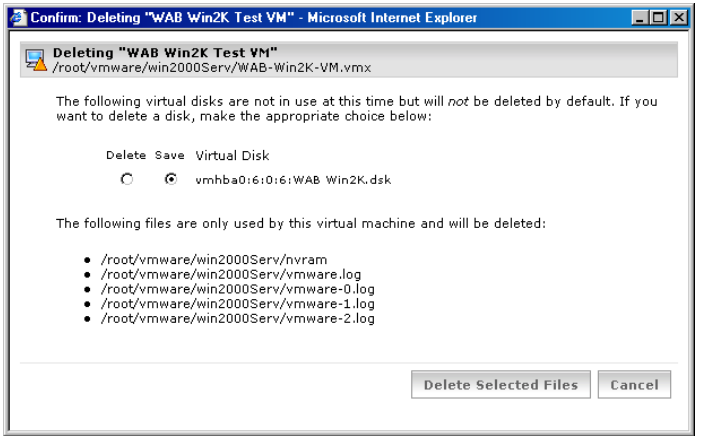
You can delete a virtual machine only if you are the root user, the owner of the configuration file, or if you have the correct permissions to the configuration file or the directory where the configuration file is located.

When you delete a virtual machine, the files associated with it — that is, located in the same directory — are deleted. These files include its configuration file (the `.vmx` file), log file and `nvram` file. The redo log and any lock files are not deleted.

Any virtual disks that are **not** associated with another registered virtual machine on the host can be deleted as well, or you can save any or all of them for future use. The directory containing these files is also deleted, unless any disk files or other files not deleted still remain.

To delete a virtual machine, complete the following steps.

1. In the VMware Management Interface, find the virtual machine you want to delete, if the virtual machine is powered on or suspended, power it off.
2. Access the virtual machine menu. Click the arrow to the right of the terminal icon ( ).
3. Choose **Delete Virtual Machine**. The Confirm: Deleting <Virtual Machine> page appears in a new window.


Confirm: Deleting "WAB Win2K Test VM" - Microsoft Internet Explorer
Deleting "WAB Win2K Test VM"
/root/vmware/win2000Serv/WAB-Win2K-VM.vmx
The following virtual disks are not in use at this time but will not be deleted by default. If you want to delete a disk, make the appropriate choice below:
Delete
Save
Virtual Disk
vmhba0:6:0:6:WAB Win2K.dsk
The following files are only used by this virtual machine and will be deleted:
/root/vmware/win2000Serv/nvram
/root/vmware/win2000Serv/vmware.log
/root/vmware/win2000Serv/vmware-0.log
/root/vmware/win2000Serv/vmware-1.log
/root/vmware/win2000Serv/vmware-2.log
Delete Selected Files
Cancel

4. All the files that are to be deleted are listed. For each disk file not associated with another registered virtual machine on this host, choose one of the following:
   - To save a virtual disk file, select the **Save** option.
   - To delete a virtual disk file, select the **Delete** option.

   Note: Any virtual disk files associated with another registered virtual machine do not appear in this window.
5. When you are ready to delete the virtual machine, click **Delete Selected Files**. The Confirm: Deleting <Virtual Machine> page closes. The virtual machine no longer appears in the management interface.

   Note: If you do not want to delete this virtual machine, click **Cancel**.

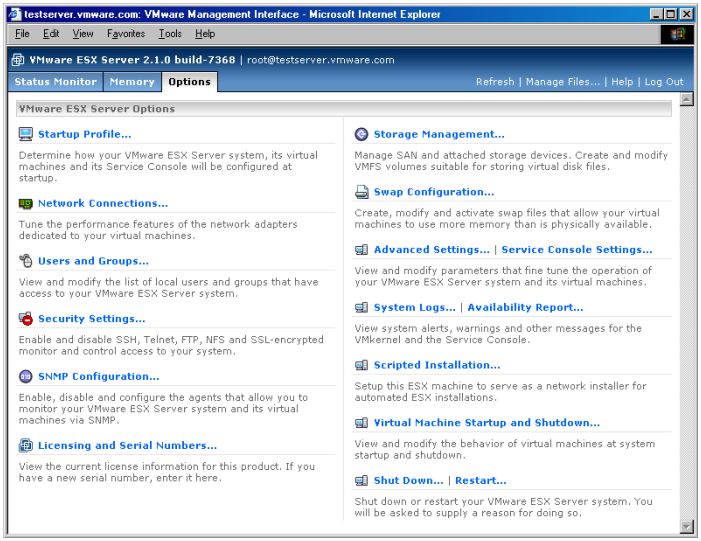
Managing ESX Server Resources

For information on managing server resources, see VMware ESX Server Resource Management on page 381.

Configuring VMware ESX Server

To configure certain VMware ESX Server settings, on the Status Monitor page, click the **Options** tab. The Options page appears.

Note: Only a user with administrator privileges (root user) can access this tab


testserver.vmware.com: VMware Management Interface - Microsoft Internet Explorer
File Edit View Favorites Tools Help
VMware ESX Server 2.1.0 build-7368 | root@testserver.vmware.com
Status Monitor
Memory
Options
Refresh | Manage Files... | Help | Log Out
VMware ESX Server Options
Startup Profile...
Determine how your VMware ESX Server system, its virtual machines and its Service Console will be configured at startup.
Network Connections...
Tune the performance features of the network adapters dedicated to your virtual machines.
Users and Groups...
View and modify the list of local users and groups that have access to your VMware ESX Server system.
Security Settings...
Enable and disable SSH, Telnet, FTP, NFS and SSL-encrypted monitor and control access to your system.
SNMP Configuration...
Enable, disable and configure the agents that allow you to monitor your VMware ESX Server system and its virtual machines via SNMP.
Licensing and Serial Numbers...
View the current license information for this product. If you have a new serial number, enter it here.
Storage Management...
Manage SAN and attached storage devices. Create and modify VMFS volumes suitable for storing virtual disk files.
Swap Configuration...
Create, modify and activate swap files that allow your virtual machines to use more memory than is physically available.
Advanced Settings... | Service Console Settings...
View and modify parameters that fine tune the operation of your VMware ESX Server system and its virtual machines.
System Logs... | Availability Report...
View system alerts, warnings and other messages for the VMkernel and the Service Console.
Scripted Installation...
Setup this ESX machine to serve as a network installer for automated ESX installations.
Virtual Machine Startup and Shutdown...
View and modify the behavior of virtual machines at system startup and shutdown.
Shut Down... | Restart...
Shut down or restart your VMware ESX Server system. You will be asked to supply a reason for doing so.

On this page are options that allow you to configure ESX Server. For detailed information on each of these links, see Administering ESX Server on page 215.

Click the **Status Monitor** tab to return to the Status Monitor page.

Logging Out of the VMware Management Interface

When you are ready to log out of the VMware Management Interface, click **Logout** on the Status Monitor or Options page. You are prompted to confirm that you want to log out. Logging out does not affect the virtual machines on the host or any remote consoles you opened from the management interface.

VMware Management Interface sessions expire automatically after 60 minutes of inactivity or idle time.

Using the Apache Web Server with the Management Interface

On VMware ESX Server, an Apache server is installed with the VMware Management Interface. These are the commands to start, stop or restart the Apache server.

In order to use these commands, you must first log in as root (`su -`).

To start the Apache server, type

```
/etc/init.d/httpd.vmware start
```

To stop the Apache server, type

```
/etc/init.d/httpd.vmware stop
```

To restart the Apache server, type

```
/etc/init.d/httpd.vmware restart
```

Setting a MIME Type to Launch the VMware Remote Console

From a browser, you can connect to a virtual machine from a remote console by clicking the terminal icon ( ) for that virtual machine. Before doing so, Netscape and Mozilla users need to define a MIME type of `x-vmware-console` and associate it with the remote console program file. Internet Explorer is automatically configured when you install the console.

Setting the MIME Type in Netscape 7.0 and Mozilla 1.x

If you are using Netscape 7.0 or Mozilla 1.x and want to launch the VMware Remote Console from the VMware Management Interface, you must first set a MIME type for the remote console program.

The procedure is similar for Windows and Linux hosts. Both involve writing a short script that provides the command to launch the remote console.

In Netscape or Mozilla, follow these steps to set the MIME type.

1. Open a text editor and do one of the following.

   On a Windows host, write a short batch file called `vmwareConsole-helper.bat`.

   The batch file must contain the following line:

   ```
   "<path_to_vmwareConsole>" -o "%1"
   ```

   where the default `<path_to_vmwareConsole>` is

   ```
   C:\Program Files\VMware\VMware Remote Console\vmwareConsole.exe
   ```

   - On a Linux host, write a short shell script called `vmware-console-helper.sh`.

     The shell script must contain the following two lines:

     ```
     #!/bin/sh
     "<path_to_vmware-console>" -o $1 > /dev/null 2>&1;
     ```

     where the default `<path_to_vmware-console>` is `/usr/bin/vmware-console`.

2. Save the file in a location of your choice.

   Note: On a Linux host, change to the directory where you saved the file and give yourself permission to execute the file.

```
chmod +x vmware-console-helper.sh
```

3. Use the browser to connect to the server you want to manage.
4. Click the terminal icon ( ) for the virtual machine you want to view in a remote console.
5. A dialog box asks what you want to do with the file. Click **Advanced**.
6. In the New Type dialog box, in the **Description of type** field, type `VMware Remote Console`.
7. In the **File extension** field, type `xvm`.
8. In the **MIME type** field, type `application/x-vmware-console`.
9. In the **Application to use** field, type the path to `vmwareConsole-helper.bat` or `vmware-console-helper.sh`.
10. Click **OK** twice. Your browser is now set to launch the remote console when you click the terminal icon in the future.

Editing a Virtual Machine's Configuration File Directly

There are two ways in which you can edit specific configuration options for a virtual machine.

- On the Options tab for a specific virtual machine, you can add and change configuration options. For more information, see Modifying the Configuration File Directly (Advanced Users Only) on page 141.
- You can also edit a virtual machine's configuration file (`.vmx`) by using a text editor in the service console. This lets you add, change and remove elements of a virtual machine's configuration.

  Caution: Modifying a configuration file by using a text editor is recommended for advanced users only. The virtual machine must be powered off. You should back up your virtual machine's configuration file before modifying it with a text editor.

Changing Your Virtual SCSI Adapter

By default, ESX Server assigns the BusLogic virtual SCSI adapter to Linux, Windows NT 4.0, Windows 2000 or Windows XP Professional guest operating systems. Similarly, ESX Server assigns the LSI Logic SCSI virtual adapter to Windows 2003 Server guest operating systems.

You can change these default settings by editing the virtual machine's configuration file through the management interface (as described in Modifying the Configuration File Directly (Advanced Users Only) on page 141).

1. Look for lines similar to the following in the virtual machine's configuration file:

   ```
   scsi0.present = "TRUE"
   scsi0.virtualDev = "vmxbuslogic"
   scsi0.sharedBus = "none"
   ```

2. Change the virtual SCSI adapter to your choice. For example, for the `scsi0.virtualDev` option, change `"vmxbuslogic"` to `"vmxlsilogic"`.
3. Click **OK** to save your change and close the Options window.

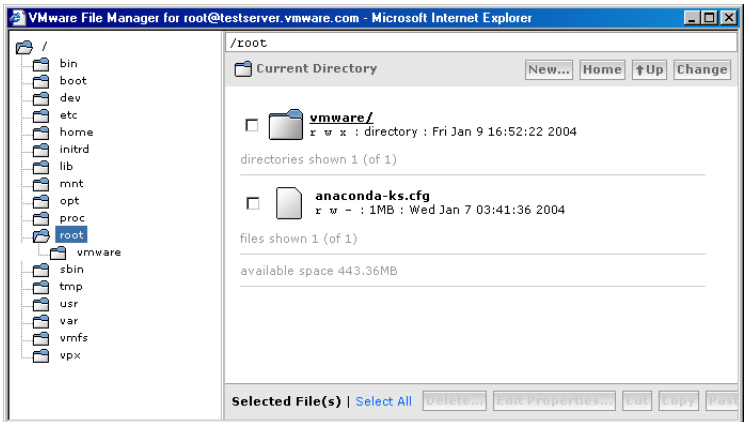
Note: If you change a virtual machine's virtual SCSI adapter to a custom adapter, your choice is retained if you change the guest operating system in the virtual machine.

If, however, you change the guest operating system on a virtual machine with a BusLogic or LSI Logic SCSI virtual adapter, the virtual SCSI adapter is updated to the default for the new guest operating system.

For example, if you have a virtual machine with a Linux operating system and change the guest operating system to Windows 2003 Server, then the virtual SCSI adapter is LSI Logic, the default virtual SCSI adapter for a Windows 2003 Server guest operating systems.

Using the VMware Management Interface File Manager

Using the VMware Management Interface, you can manage the file system of your VMware ESX Server machine remotely. Use the file manager to change the permissions of any file on the physical machine, create new directories on the physical machine or cut, copy, paste and delete files as you would if you were working directly on the file system itself. To use the file manager, click **Manage Files** on the Status Monitor or Options page of the management interface.

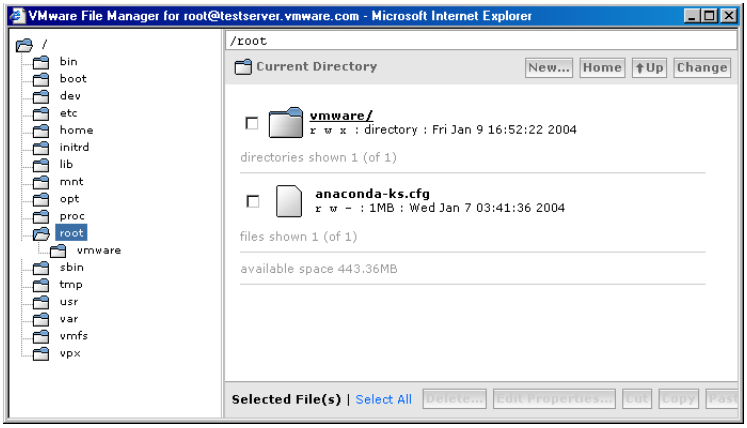


In the left pane of the file manager, click a folder to display its contents.

Note: The tree view may fail to load or may only partially load when viewed with Mozilla. To restore the proper view, right-click in the left pane, then choose **Reload Frame** or **Refresh** from the context menu.

Some file and folder icons have special meanings.

Item	Description
	This icon identifies a virtual machine configuration file. If you click the filename or icon for a configuration file, the Edit Configuration page for the corresponding virtual machine opens in a browser window.
	This icon identifies a virtual disk file on a VMFS file system.
	This icon identifies a set of files on the service console that hold a virtual disk in the format used by VMware Workstation and VMware GSX Server.
	This icon identifies a VMFS volume.



To perform an action on a file or folder (directory), click the check box beside its listing, then click the appropriate button at the bottom of the screen to delete, edit properties, cut or copy.

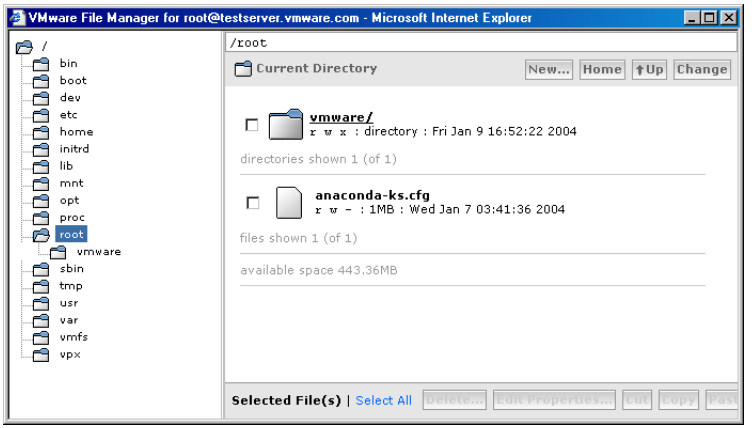
After you have cut or copied a file or folder, you may then paste it into the same or a different folder. If you copy a file or folder, then paste it into the same folder, the new file or folder is renamed, with `copy_of_` before the original name. You may then select it and use **Edit Properties** to give it a name of your choice.

When you start a long-running operation — for example, pasting a file larger than 10MB after a copy or moving it between logical file systems — a progress bar appears so you can track the progress of the operation.

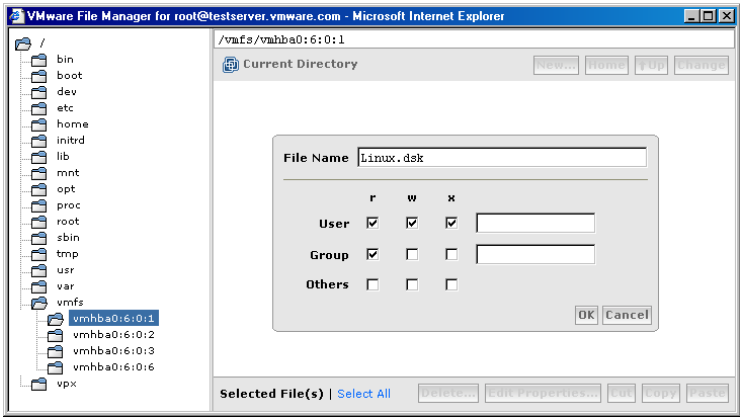
When you copy and paste or cut and paste a virtual disk file from the VMFS file system to the service console's file system, or vice versa, the file manager uses `vmkfstools` to import or export the file, translating the format appropriately. Among other things,

this means a virtual disk larger than 2GB will be split into multiple files when it is moved from a VMFS disk or array to the service console's file system.

Note: The file manager in the management interface may display incorrect information or no information at all for files larger than 2GB. This means that you cannot use the file manager to import certain virtual disk files created under VMware Workstation 4. For background on `vmkfstools`, see Using vmkfstools on page 229.

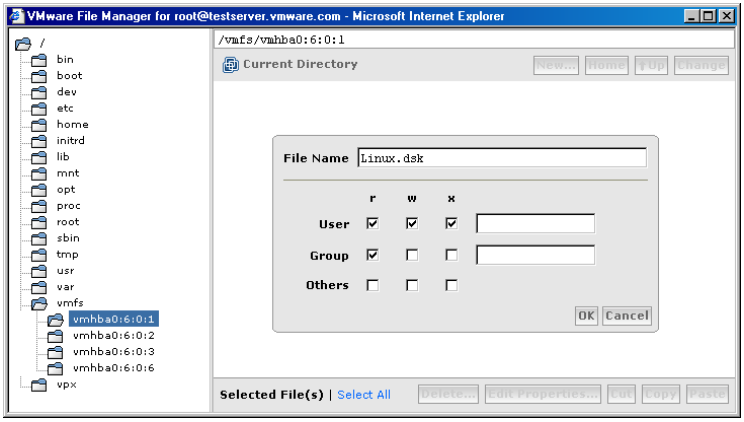


After selecting a file or folder and clicking **Edit Properties**, you can change its name and permissions. When you are finished, click **OK** to apply the changes.



If you select more than one file or folder, you can change permissions for all the files at once. Any changes you make, using the drop-down lists in the file manager, apply to all the files you have selected.

- A letter, corresponding to the letter at the top of the column (**r**ead, **w**rite or e**x**ecute), indicates that the setting is the same for all files and it does grant the permission indicated by the letter.
- A hyphen (-) indicates that the setting is the same for all files and it does not grant permission.
- A blank space indicates that the setting is not the same for all files.



Use the top pane of the file manager to navigate the directory structure and create new directories.

To create a new directory, click **New**, enter the name for the directory, then click **OK**.

Setting Permissions for Owners of Virtual Machines

The VMware Management Interface uses the permissions of the virtual machine's configuration (`.vmx`) file to determine the privileges a user has on a particular virtual machine. The user needs read (**r**) access to view the virtual machine, write (**w**) access to modify the virtual machine's configuration parameters and execute (**x**) access to perform power operations on the virtual machine. In addition, the user needs read, write and execute access to register or unregister the virtual machine. See Registering and Unregistering Virtual Machines on page 168.

Previous versions of ESX Server checked the access permissions of the virtual machine's configuration file and the access permissions of the directory in which the configuration (`.vmx`) file was located. In other words, the user needed execute (**x**) permissions on all the parent directories for a configuration file.

For example, if a configuration file is `/home/foo/vms/win2k/win2k.vmx`, the user needed to have execute (**x**) privileges on `/home`, `/home/foo`, `/home/foo/vms`, `/home/foo/vms/win2k` and appropriate privileges on `win2k.vmx`.

Note: The remote console still requires that the user has execute (**x**) permission on all parent directories.

Creating a Flagship User

You might choose to have a virtual machine owned by a "flagship user" instead of a real person. By using a "flagship user," only one user account owns the virtual machines that are in production. An advantage of using flagship accounts is that flagship users never leave the company or go on vacation.

By using a flagship user, you also avoid problems in access privileges, if multiple individuals in a group, access the same virtual machine, through the remote console. That is, you can give all group members execute privileges to the flagship user's directories. that contain the virtual machines. Without these execute privileges on parent directories, other group members won't be able to use the remote console.

Registering and Unregistering Virtual Machines

ESX Server requires that each virtual machine's configuration file be registered before it can be accessed by VMware Remote Consoles and the VMware Management Interface. When you create a new configuration file with the management interface, whether for a new or an existing virtual machine, the configuration file is registered automatically with ESX Server.

You can have up to 80 registered virtual machines on a server at one time. If you intend to run more than 60, you must modify some service console settings. See Running Many Virtual Machines on ESX Server on page 170.

When you register a virtual machine, it appears in the management interface and the Connect to VMware Virtual Machine dialog box that appears when you connect to the virtual machine with the remote console.

If you are using a virtual machine that you migrated from another server or VMware product, you must register the configuration file as described below. For more information about migrating virtual disks and virtual machines, see Importing, Upgrading and Exporting Virtual Machines on page 64.

If you do not have a current need for a virtual machine, you can unregister it instead. This is useful if you have more than 80 virtual machines on the server and do not want to delete any excess virtual machines. An unregistered virtual machine no longer appears in the management interface and cannot be connected to by a remote console.

You must have full permissions to the virtual machine's configuration file (`.vmx`) in order to register or unregister it.

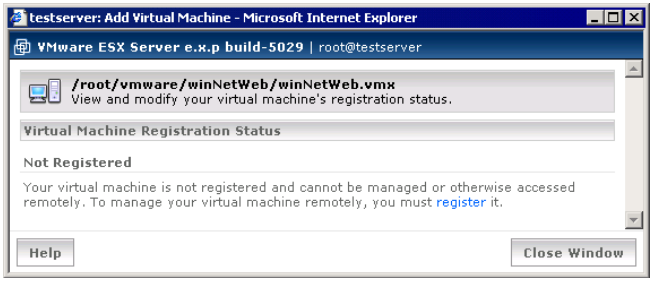
Registering a Virtual Machine

Virtual machines created on the server are automatically registered. If you imported a virtual machine from another server or from another VMware product, or if you previously unregistered a virtual machine, you can register it by completing the following steps.

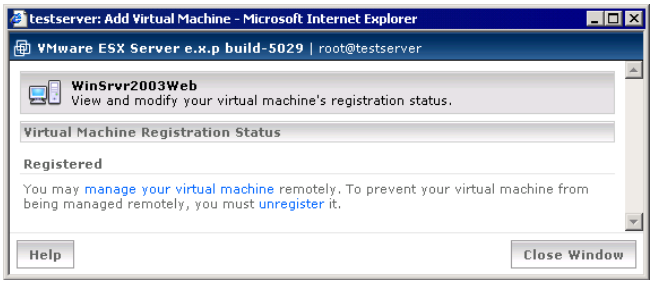
1. Log into the management interface as the user with full permissions to the virtual machine's configuration file.

Note: Only the root user can register and unregister virtual machines through the management interface. However, regular users can register and unregister virtual machines by using the scripting API.

2. On the Status Monitor page, click **Manage Files**. The file manager appears.
3. Browse to the directory containing the configuration file (the file with the `.vmx` extension) and click the configuration file icon. The Virtual Machine Registration Status window appears, indicating the virtual machine is not registered.


testserver: Add Virtual Machine - Microsoft Internet Explorer
VMware ESX Server e.x.p build-5029 | root@testserver
/root/vmware/winNetWeb/winNetWeb.vmx
View and modify your virtual machine's registration status.
Virtual Machine Registration Status
Not Registered
Your virtual machine is not registered and cannot be managed or otherwise accessed remotely. To manage your virtual machine remotely, you must register it.
Help
Close Window

4. Click the **register** link in the window. The window indicates the virtual machine is registered.


testserver: Add Virtual Machine - Microsoft Internet Explorer
VMware ESX Server e.x.p build-5029 | root@testserver
WinSrvr2003Web
View and modify your virtual machine's registration status.
Virtual Machine Registration Status
Registered
You may manage your virtual machine remotely. To prevent your virtual machine from being managed remotely, you must unregister it.
Help
Close Window

5. Click **Close Window**. The virtual machine appears on the Status Monitor page and you can connect to it with a remote console.

Unregistering a Virtual Machine

To unregister a virtual machine, complete the following steps.

1. Log into the management interface as the user with full permissions to the virtual machine's configuration file.
2. On the Status Monitor page, on the row for the virtual machine, click the arrow to the right of the terminal icon ( ). The virtual machine menu appears.
3. Click **Unregister Virtual Machine**. The virtual machine no longer appears on the Status Monitor page and cannot be remotely managed.

Running Many Virtual Machines on ESX Server

If you plan to run or register more than 60 virtual machines, you must change a few settings in the service console. By changing these settings, you provide additional CPU and memory resources to the service console, allowing ESX Server to operate more efficiently under this higher load.

Note: If you decrease the number of registered or running virtual machines to less than 60, then you should revert the settings back to their defaults through the management interface or through the service console.

Increasing the Memory in the Service Console

1. Log into the VMware Management Interface as root.
2. Click the **Options** tab, then click **Startup Profile**.
3. Increase the **Reserved Memory** to at least 512MB, and up to 800MB (the maximum recommended setting).
4. Click **OK**, then reboot ESX Server.

   For more information, see Service Console Memory on page 424.

Allocating CPU Resources to the Management Interface

If, after changing these settings, you are still unable to open the VMware Management Interface to your server, then the number of outstanding processes, that are waiting to be executed, is too high. You need to allocate the necessary CPU resources to the management interface, by increasing the priority for the vmware-serverd and httpd processes.

1. Log in as the root user on the service console.
2. Type ps auxw and find the process IDs of the `httpd` and `vmware-serverd` processes.

   If there are multiple httpd processes, then type `top`. Click Shift-p (P) to sort the output by CPU usage. Remember the process ID for the `httpd` process using the most CPU.
3. Raise the vmware-serverd process priority to -15 so that it can connect to all running virtual machines:

   ```
   renice -15 -p <vmware-serverd_process_ID>
   ```
4. Raise the `httpd` process priority to -15:

```
renice -15 -p <httpd_process_ID>
```

5. Verify that you can log into the VMware Management Interface and view correct information about the virtual machines. Once this occurs, then continue with the next step.
6. Change the `vmware-serverd` process priority back to the default of zero (0).

   ```
   renice 0 -p <vmware-serverd_process_ID>
   ```

7. Change the `httpd` process priority back to the default of zero (0).

   ```
   renice 0 -p <httpd_process_ID>
   ```

Changing Default Parameters in the config File

Add the following configuration parameters in the `/etc/vmware/config` file.

Note: If you decrease the number of registered or running virtual machines to less than 60, then you should comment out the new lines you added or delete them from the `/etc/vmware/config` file.

Increasing Memory to the Apache Process

By default, Apache allocates a shared memory segment of 24MB to contain all the virtual machines' data. This value of 24 MB is sufficient for 80 virtual machines. If you have more than 80 (up to the maximum of 200) registered virtual machines, Apache may run out of memory. If that happens, you may see a "Panic out of memory" message in `/usr/lib/vmware-mui/apache/logs/error_log` and the VMware Management Interface shuts down.

1. Use a text editor and add the following option to `/etc/vmware/config`:

   ```
   mui.vmdb.shmSize = "37748736"
   ```

   where 37748736 represents 36MB (36 multiplied by 1024, multiplied by 1024).

2. Restart the Apache server.

   ```
   /etc/rc.d/init.d/httpd.vmware restart
   ```

Note: Increasing this value may impact the performance of the virtual machines, since the Apache processes will require more memory in the service console.

Increasing the Timeout Value for the vmware-authd Process

As root, use a text editor and add the following configuration parameter to the `/etc/vmware/config` file:

```
vmauthd.connectionSetupTimeout = 120
```

This increases the timeout value to 2 minutes from the default of 30 seconds.

Increasing Memory for the vmware-serverd Process

As root, use a text editor and add the following configuration parameter to the `/etc/vmware/config` file:

```
vmserverd.limits.memory = "49152"
vmserverd.limits.memhard = "65536"
```

These changes raise the soft memory limit for the `vmware-serverd` process to 48 MB (48 multiplied by 1024) and the hard memory limit to 64 MB (64 multiplied by 1024).

Note: You must restart the `vmware-serverd` process by rebooting ESX Server or by logging in to the service console as root and issuing the command

```
killall -HUP vmware-serverd
```

Running Many Virtual Machine with a Significant CPU Load

If you plan to run a large number of virtual machines with applications that use a significant amount of CPU, then increase the service console shares to 10000.

1. Log into the VMware Management Interface as the root user.
2. Click the **Options** tab, then click **Service Console Settings**.

   The CPU page should be displayed. If not, click the **CPU** tab.
3. Click **Edit**.
4. Type 10000 in the **Shares** field and click **OK**.

If the management interface is unresponsive, then you need to make these changes through the service console.

1. Log into the service console as the root user.
2. Type `cat /proc/vmware/sched/cpu`.
3. Find the line that has `console` for the name. For example:

```
vcpu    vm        name          uptime      status      ...
125     125       console       71272.378   RUN         ...
126     126       idle1         71272.378   RUN         ...
127     127       idle2         71272.378   RUN         ...
```

4. Use the echo command to change the number of service console shares:

   `echo 10000 > /proc/vmware/vm/<name>/cpu/shares`

   For the preceding output, you would type:

   `echo 10000 > /proc/vmware/vm/125/cpu/shares.`

Avoiding Management Interface Failures when Many Virtual Machines Are Registered

If you have a very large number of virtual machines registered on a single ESX Server machine, the VMware Management Interface may shut down and a `Panic out of memory` message may be recorded in `/usr/lib/vmware-mui/apache/logs/error_log`.

By default, the Apache Web server uses 24MB of memory to store information about the virtual machines on the server. The errors described above can happen when this memory is not adequate for the number of virtual machines.

To work around the problem, open the file `/etc/vmware/config` in a text editor and find the line that begins with `mui.vmdb.shmSize =`. Increase the number in quotation marks, which is specified in bytes of memory. Then restart the Apache server with the following command:

```
/etc/rc.d/init.d/httpd.vmware restart
```

Backing Up Virtual Machines

Your backup strategy depends on how you want to protect your data and recover from problems. There are two main goals.

- Recover individual files on the virtual machine (for example, if a user accidentally removes a file)
- Recover from catastrophic failures in which your entire virtual machine is damaged

VMware ESX Server provides several possible approaches for backing up your data, whether to tape or to another system over the network. You will probably find that a combination of approaches provides the best data protection for your virtual machines.

The next section, Using Tape Drives with VMware ESX Server, describes how to make tape drives available to both your virtual machine and your service console:

- Backing Up from within a Virtual Machine on page 174
- Backing Up Virtual Machines from the Service Console on page 175
- Using Hardware or Software Disk Snapshots on page 175
- Using Network-based Replication Tools on page 176

Using Tape Drives with VMware ESX Server

The management interface allows you to allocate a SCSI controller to the service console, to one or more virtual machines or for use by both environments. To make a SCSI tape drive available in a virtual machine, you must allocate the SCSI controller to which it is attached for use only by virtual machines.

You can check the allocation settings for the server's SCSI controllers in the management interface. On the Status Monitor page, click the **Options** tab, then click **Startup Profiles**.

Caution: Do not reassign a server's only SCSI controller if the service console is running from a drive attached to that controller. If your system is configured this way, you must add a second SCSI controller to control the tape drive.

Backing Up from within a Virtual Machine

One approach to backing up your data is to back up a particular virtual machine's data just as if it were on a physical machine. To do so, you can run either a direct backup tool or the client component of a client-server backup tool within the virtual machine and configure it for direct access to the network or tape drive.

Note: You can also use a virtual machine to run the server component of a client-server backup product, provided you give it access to one or more tape drives.

Backing up from within a virtual machine has the benefit of allowing fine-grained recovery of your data.

- You can restore file data by the individual file.
- You can restore database data via the normal database-specific method.

However, if there is a disaster and you need to restore the virtual machine from a backup made from within the virtual machine, you need to recreate the virtual machine and load recovery software into it before restoring data from the backups.

To configure a virtual machine so you can use a tape drive from within it, see Adding a Tape Drive to a Virtual Machine on page 136.

Backing Up Virtual Machines from the Service Console

You may also choose to back up your virtual machines by copying to tape the entire virtual disk files and any redo logs, along with the backups of the service console. This approach has the benefit of making it easy to restore your virtual machines in the event of a full system loss or data loss due to failure of unprotected disks.

However, these full-image backups do not permit you to restore individual files. You must restore the entire disk image and any associated logs, then power on a virtual machine with these drives connected to retrieve specific data.

The next section describes how to ensure data integrity when backing up virtual machines from the physical computer or the service console.

Providing Optimum Data Integrity In Virtual Machine Backups Without Downtime

You can use the VMware Scripting API included with ESX Server 2.1 in conjunction with backup products to provide snapshots, or stable disk or redo log images. The appropriate functions can be called from within many backup products in order to establish a safe basis for backing up images or logs. You may use this approach with any disk mode — persistent, undoable, nonpersistent or append.

For information on the Scripting API, see the VMware Scripting API documentation at *www.vmware.com/support/developer/scripting-API/doc/Scripting_API.pdf*.

Using Hardware or Software Disk Snapshots

You may choose to use the snapshot capabilities offered by your disk subsystem, file system or volume manager to provide stable copies of disk images. As with physical

servers, consider using some level of application integration so you can be sure your backups have the desired level of data integrity.

You can combine these approaches with the ESX Server redo log API (described in Providing Optimum Data Integrity In Virtual Machine Backups Without Downtime on page 175) to keep the interval during which an extra log is used to a minimum. To do this, take the following general steps:

- Add the new redo log.
- Take a snapshot of the mirror using your disk subsystem's or volume manager's interfaces.
- Commit the changes to the live log.

You may still back up from the stable disk image on the snapped mirror, then reconnect the mirror to have it pick up the latest changes in time for your next backup.

Using Network-based Replication Tools

Many enterprise disk storage subsystems can be configured to replicate, or mirror, their data to another subsystem at a local or remote location. This replication can occur either synchronously or asynchronously.

- If the replication is synchronous, a write operation does not appear to be completed locally until the data is committed to disk at the remote location.
- This improves data integrity but presents a potential performance bottleneck.
- If the replication is asynchronous, the remote copy is permitted to be some number of write operations behind the most current local data.
- This accepts a higher potential of inconsistent data at the remote site in exchange for increased performance.

Either of these hardware-based approaches may be used with ESX Server.

In addition, some disaster protection software products implement remote mirroring in software. These tools provide protection and data integrity semantics similar to those of the hardware-based solutions. However, they may be more cost-effective for configurations with low to medium performance requirements.

These software tools can be used inside guest operating systems.

Note: We recommend that you do not use software remote mirroring tools for service console-driven replication on VMware ESX Server. This is because these software tools usually require file system format awareness, add significantly to the

network I/O level and the CPU requirements to service that network I/O, and are more common on Windows and Unix operating systems than on Linux.

CHAPTER 4

Using the VMware Remote Console

The following sections describe various aspects of using the VMware Management Interface:

- Starting the Remote Console on Windows on page 180
- Starting the Remote Console on Linux on page 180
- Running a Virtual Machine Using the Remote Console on page 181
- Special Power Options for Virtual Machines on page 182
- VMware Tools Settings on page 184
- Installing New Software Inside the Virtual Machine on page 188
- Cutting, Copying and Pasting on page 189
- Suspending and Resuming Virtual Machines on page 189
- Shutting Down a Virtual Machine on page 191

Using the Remote Console

The remote console gives you a direct window into an individual virtual machine running under VMware ESX Server. Remote console software is available for Windows XP, Windows 2000, Windows NT and Linux management workstations. For instructions on installing the software, see Installing the Remote Console Software on page 75.

You can connect up to three remote consoles to a virtual machine at a time, and up to 80 remote consoles can be connected to the server at a time.

Starting the Remote Console on Windows

1. Start the remote console program.

   Start > Programs > VMware > VMware Remote Console

2. A dialog box asks for the information needed to connect you to the virtual machine. Fill in the blanks with
   - The host name (or IP address)
   - Your user name
   - Your password

   Click **Connect**.

3. When the connection is made, a dialog box displays the paths to the configuration files of virtual machines registered on the server. Select the virtual machine you want to connect to, then click **OK**.

Note: If you launch the remote console from the management interface from Internet Explorer 6.0 on a system where SSL is encrypting your ESX Server remote connections, you need to configure Internet Explorer. See Launching the Remote Console from the Management Interface on an Encrypted Server on page 90.

Starting the Remote Console on Linux

1. Start the remote console program.

   ```
   vmware-console
   ```

2. A dialog box asks for the information needed to connect you to the virtual machine. Fill in the blanks with
   - The host name (or IP address)
   - Your user name
   - Your password

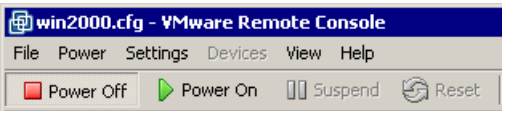
   Click **Connect**.

3. When the connection is made, a dialog box displays the paths to the configuration files of virtual machines registered on the server. Select the virtual machine you want to connect to, then click OK.

Running a Virtual Machine Using the Remote Console

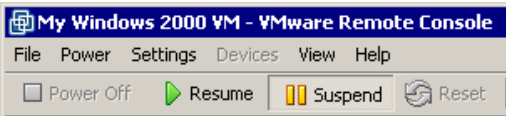
When you view your virtual machine through a remote console, it behaves much like a separate computer that runs in a window on your computer's desktop.

Instead of using physical buttons to turn this computer on and off, you use buttons at the top of the VMware console window. You can also reset the virtual machine, suspend a virtual machine and resume a suspended virtual machine.



This virtual machine is powered off

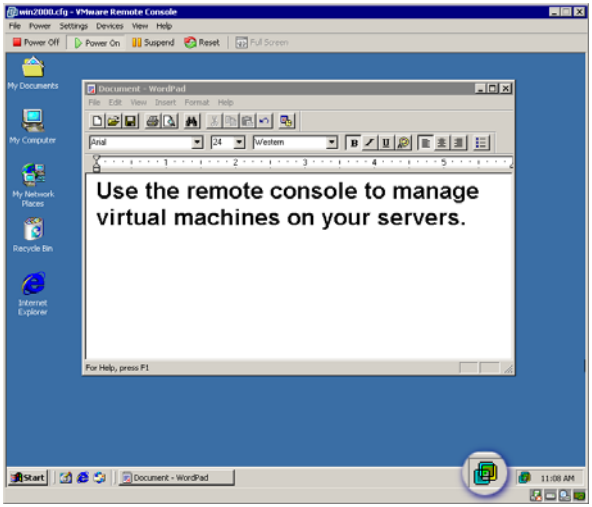
This virtual machine is powered on



This virtual machine is suspended

Note: The illustrations above show the toolbar from a remote console running on a Windows management workstation. If you are running the remote console on a Linux

management workstation, the appearance of the toolbar is somewhat different, but the same functions are available.



When VMware Tools for Windows is running, the VMware Tools icon appears in the system tray

Special Power Options for Virtual Machines

When VMware Tools is running, you can run scripts when you change the power state of a virtual machine; that is, when you power on, power off, suspend or resume the virtual machine. For more information, see Executing Scripts When the Virtual Machine's Power State Changes on page 77.

When you reset a virtual machine, you can choose to restart the guest operating system, which gracefully closes applications and restarts the guest operating system, or reset the virtual machine, which is the same as pressing the reset button on a physical computer.

Similarly, when you power off the virtual machine, you can choose to shut down the guest operating system, which gracefully closes applications and shuts the guest operating system down, or turn off the virtual machine, which is the same as pressing the power button on a physical computer.

All the power options are available on the Power menu. Each menu item corresponds to a button on the toolbar, and opens a submenu containing the associated options. The menu items may not be available, depending upon the current power state of the virtual machine. For example, if the virtual machine is powered off, you cannot select any power off, suspend, resume or reset options.

From a remote console, you can choose from the following options when powering on a virtual machine:

- Power On Virtual Machine — powers on the virtual machine in the remote console. This is the same as clicking the **Power On** button on the toolbar.
- Power On Then Run Script — powers on the virtual machine in a remote console, then executes the associated script.

Options for Powering Off a Virtual Machine

You can choose from the following options when powering off a virtual machine:

- Power Off Virtual Machine — powers off the virtual machine. This is similar to turning off a physical computer by pressing its power button, so any programs running in the virtual machine may be adversely affected. Clicking the **Power Off** button on the toolbar powers off the virtual machine.
- Shut Down Guest Operating System — gracefully shuts the guest operating system down and, if the guest operating system supports Advanced Power Management, powers off the virtual machine. If there is a script associated with this power operation, it executes after the shut down begins. This is the same as choosing **Start** > **Shut Down** > **Shut Down** in a Windows operating system or issuing a `shutdown` command in a Linux operating system.

Options for Suspending a Virtual Machine

You can choose from the following options when suspending a virtual machine:

- Run Script Then Suspend — executes the associated script, then suspends the virtual machine. This is the same as clicking **Suspend** on the toolbar, unless a script is not associated with suspending a virtual machine.
- Suspend Virtual Machine — suspends the virtual machine.

Option for Resuming a Virtual Machine

You can choose the following option when resuming a virtual machine:

- Resume Then Run Script — resumes the suspended virtual machine, then executes the associated script. This is the same as clicking **Resume** on the toolbar, unless a script is not associated with resuming a virtual machine.
- Resume Virtual Machine — resumes the suspended virtual machine.

Options for Resetting a Virtual Machine

You can choose from the following options when resetting a virtual machine:

- Reset Virtual Machine — resets the virtual machine. This is similar to resetting a physical computer by pressing its reset button, so any programs running in the

virtual machine may be adversely affected. Clicking the **Reset** button on the toolbar resets the virtual machine.

- **Restart Guest Operating System** — gracefully restarts the virtual machine. If there is a script associated with shutting down the guest operating system, it executes after the guest operating system restarts. This is the same as choosing **Start** > **Shut Down** > **Restart** in a Windows operating system or issuing a `reboot` command in a Linux operating system.

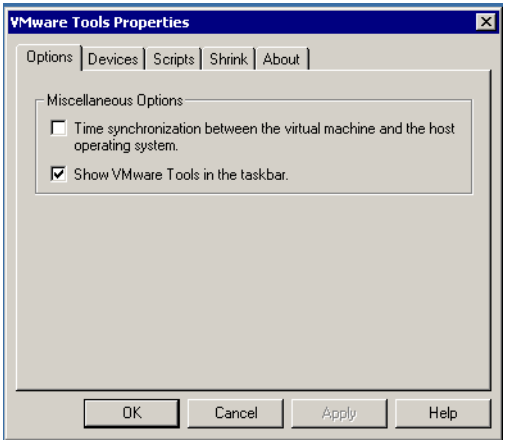
VMware Tools Settings

The following description of the settings for VMware Tools is based on a Windows 2000 guest operating system. Similar configuration options are available in VMware Tools for other guest operating systems.

To open the VMware Tools control panel, double-click the VMware Tools icon in the virtual machine's system tray. The VMware Tools Properties dialog box appears.

Setting Options with VMware Tools

You can specify time synchronization and the display of the VMware Tools icon in the Options tab.



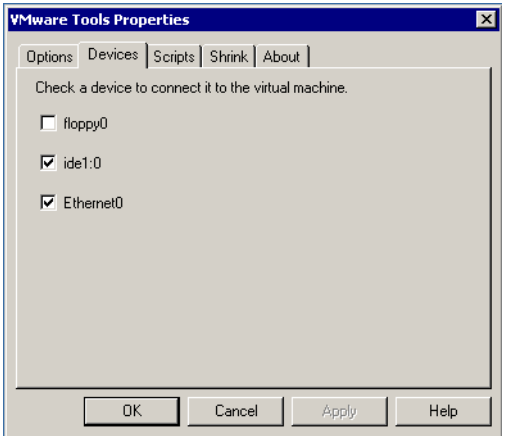
- Time synchronization — You can specify whether you want to synchronize the time in the guest operating system with the time in the service console.

  Note: You can synchronize the time in the guest operating system with the time in the service console only when the time in the guest is earlier than the time in the service console.

- VMware Tools icon display in the taskbar — If you choose not to display the VMware Tools icon in the system tray, you can launch the control panel from the Start menu (**Start** > **Settings** > **Control Panel** > **VMware Tools**).

Connecting Devices with VMware Tools

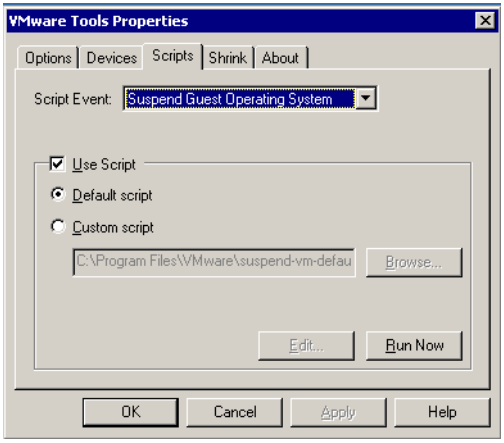
You can enable or disable removable devices in the Devices tab.



The devices you can enable or disable include the server machine's floppy disk drive, the CD-ROM drive and the virtual network interface card. You can also set these options from the Devices menu of the ESX Server remote console window.

Choosing Scripts for VMware Tools to Run During Power State Changes

Through VMware Tools, you can run scripts that execute when you power on, power off, suspend or resume the virtual machine.



A default script for each power state is included in VMware Tools. These scripts are located in the guest operating system in `C:\Program Files\VMware`.

When You …	This Default Script Runs
Suspend the guest operating system	`suspend-vm-default.bat`
Resume the guest operating system	`resume-vm-default.bat`
Shut down the guest operating system	`poweroff-vm-default.bat`
Power on the guest operating system	`poweron-vm-default.bat`

For each power state, you can use the default script or you can substitute a script you created. In addition, you can test a script or disable the running of a script. Complete the following steps.

1. In the **Script Event** list, select the power operation with which to associate the script.
2. Do one of the following:
   - To select a different script, click **Custom Script**, then click **Browse** and select the new script.
   - To edit a script, click **Edit**. The script opens in your default editor. Make your changes there.
   - To test the script, click **Run Now**.

- To disable the running of a script, uncheck the **Use Script** check box.

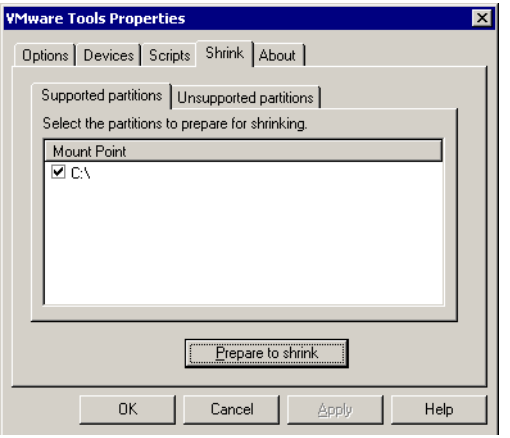
3. Click **Apply** to save your settings.

Shrinking Virtual Disks with VMware Tools

The Shrink tab lets you prepare to export a virtual disk to VMware GSX Server using the smallest possible disk files. This step is an optional part of the export process.

Virtual disks on ESX Server take up the full amount of disk space indicated by the virtual disk's size. In other words, the `.dsk` file for a 4GB virtual disk occupies 4GB of disk space.

GSX Server works differently. Under GSX Server, virtual disk files start small — only as big as needed to hold the data stored on the virtual disk — and grow as needed up to the designated maximum size.

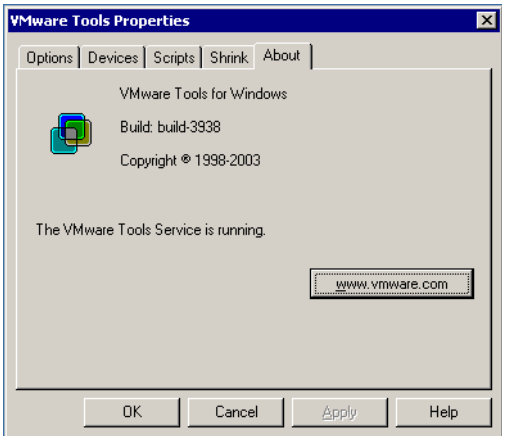


If you plan to export a virtual disk for use under GSX Server, click the Shrink tab, be sure there is a check beside the name of the disk you plan to export, then click **Prepare to shrink**.

Note: When you export the virtual disk (using the file browser in the management interface or the `vmkfstools` command), a single virtual disk may be exported to multiple `.dsk` files.

Viewing Information About VMware Tools

On the About tab, you see general information about VMware Tools installed in the virtual machine.



This tab contains the following information:

- The VMware Tools build number, which lets you verify your VMware Tools version matches the VMware ESX Server version you are running and is useful when you request support.
- An indication as to whether the VMware guest operating system service is running.
- A button you click to visit the VMware Web site.

Installing New Software Inside the Virtual Machine

Installing new software in an ESX Server virtual machine is just like installing it on a regular computer.

If you are using physical media, you need to have access to the ESX Server computer to insert installation CD-ROM discs or floppy disks into the server's drives.

You may use image files in place of physical floppy disks and CD-ROM discs. To connect the virtual drive to a floppy or ISO image, use the Devices menu and edit the settings for the drive you want to change.

The following steps are based on using a Windows guest operating system and physical media. If you are using a Linux guest operating system — or if you are using ISO or floppy image files — some details are different.

1. Be sure you have started the virtual machine and, if necessary, logged on. Check the Devices menu to be sure the virtual machine has access to the CD-ROM and floppy drives.
2. Insert the installation CD-ROM or floppy disk into the proper drive. If you are installing from a CD-ROM, the installation program may start automatically.
3. If the installation program does not start automatically, click the Windows **Start** button, go to **Settings > Control Panel**, then double-click **Add/Remove Programs** and click **Add New Programs**. Follow the instructions on screen and in the user manual for your new software.

Cutting, Copying and Pasting

Be sure you have installed and started VMware Tools in your virtual machine.

In a Windows guest operating system, you see a VMware Tools icon in the system tray when VMware Tools is running.

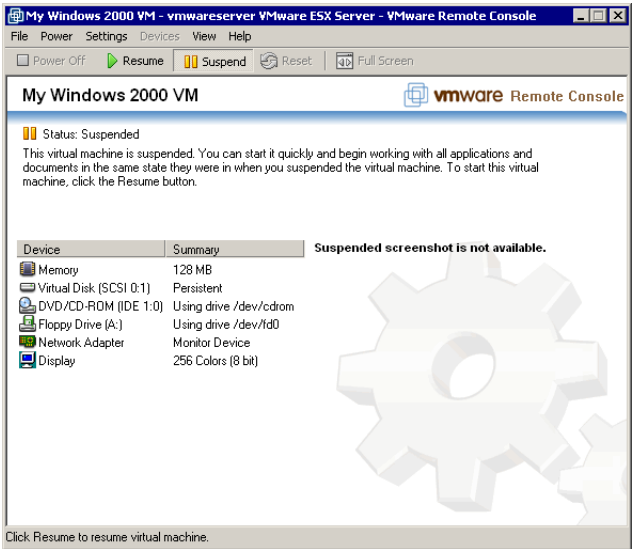
When VMware Tools is running, you can copy and paste text between applications in the virtual machine and on your management workstation or between two virtual machines. Use the normal hot keys or menu choices to cut, copy and paste.

Suspending and Resuming Virtual Machines

You can save the current state of your virtual machine. Then the resume feature lets you quickly pick up work right where you stopped — with all running applications in the same state they were at the time you suspended the virtual machine.

There are two ways to suspend a virtual machine:

- With a remote console connected to that virtual machine, click **Suspend** on the toolbar.


My Windows 2000 VM - vmwareserver VMware ESX Server - VMware Remote Console
File Power Settings Devices View Help
Power Off Resume Suspend Reset Full Screen
My Windows 2000 VM
vmware Remote Console
Status: Suspended
This virtual machine is suspended. You can start it quickly and begin working with all applications and documents in the same state they were in when you suspended the virtual machine. To start this virtual machine, click the Resume button.
Device Summary
Memory 128 MB
Virtual Disk (SCSI 0:1) Persistent
DVD/CD-ROM (IDE 1:0) Using drive /dev/cdrom
Floppy Drive (A:) Using drive /dev/fd0
Network Adapter Monitor Device
Display 256 Colors (8 bit)
Suspended screenshot is not available.
Click Resume to resume virtual machine.

- With the VMware Management Interface connected to the virtual machine's server, click the pause button ( ) on the row for that virtual machine.

There are two ways to restore a virtual machine that you have suspended:

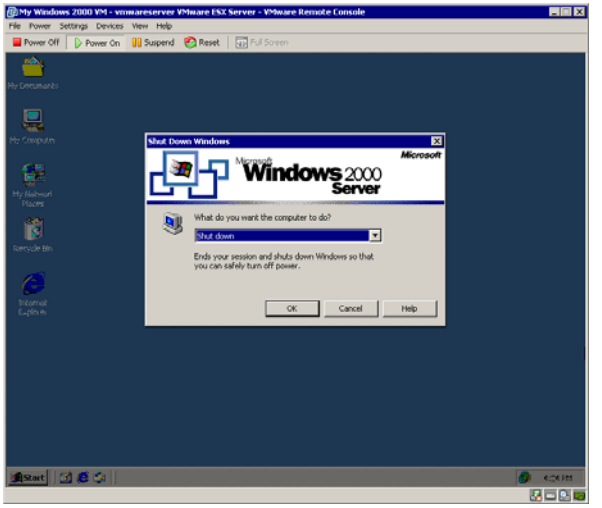
- With a remote console connected to that virtual machine, click **Resume** on the toolbar.
- With the VMware Management Interface connected to the virtual machine's server, click the pause button ( ) on the row for that virtual machine.

You can also set your virtual machine so it always resumes in the same state. For details, see Enabling Repeatable Resume on page 99.

Shutting Down a Virtual Machine

The following steps are based on using a Windows 2000 or Windows NT guest operating system. If you are using a Linux guest operating system, follow the usual steps to shut down the guest operating system inside your virtual machine.

1. Select **Shut Down** from the **Start** menu of the guest operating system (inside the virtual machine).



2. Select **Shut Down**, then click **OK**.

CHAPTER 5

Using the VMware Service Console

The following sections describe various aspects of using the VMware Service Console:

- Characteristics of the VMware Service Console on page 194
- Managing the Service Console on page 195
- Authentication and Security Features on page 207
- Using Devices With ESX Server on page 211
- Enabling Users to View Virtual Machines Through the VMware Remote Console on page 213

Characteristics of the VMware Service Console

The purpose of the VMware service console is to start up and administer your virtual machines. It is a customized version of Linux based on the Red Hat 7.2 distribution. It has been modified so it can be managed by the VMkernel.

The service console has been customized to disable unneeded services. In particular, most network services have been disabled, except for auth. For remote access to the service console, ssh is enabled by default. The root user can modify settings for ssh, Telnet and FTP using the security configuration page in the management interface (`http://<servername>/security-config`).

The service console is scheduled by the VMkernel just as any other virtual machine is. You should not attempt to run heavy workloads on the service console, because it may take processor cycles away from your virtual machines.

Using DHCP for the Service Console

The recommended setup is to use static IP addresses for the service console. It is also possible to set up the service console to use DHCP, so long as your DNS server is capable of mapping the service console's host name to the dynamically-generated IP address.

If your DNS server cannot map the host's name to its DHCP-generated IP address, which may be the case, you must determine the service console's numeric IP address yourself and use that numeric address when accessing the management interface's Web pages.

Keep in mind that the numeric IP address may change as DHCP leases run out or when the system is rebooted. For this reason, we do not recommend using DHCP for the service console unless your DNS server can handle the host name translation.

Caution: Do not use dynamic (DHCP) addressing when sharing the network adapter assigned to the Service Console with Virtual Machines. ESX Server requires a static IP address for the Service Console when sharing a network adapter.

Managing the Service Console

The command summary in this section provides an introduction to the commands you are most likely to use at the service console. Some are specific to ESX Server. Most are commands that are the same as those you would use at a Linux command line.

Connecting to the Service Console

If you have direct access to the computer where ESX Server is running, you can log in to the physical console on that computer. Press Alt-F2 to get to the login screen.

Depending on the security settings for your ESX Server computer, you may be able to connect remotely to the service console using SSH or Telnet. For more information on the security settings, see Detailed usage notes for most service console commands are available as manual — or man — files. To view the manual file — or man page — for a particular command, use the `man` command followed by the name of the command for which you want to see information. on page 206.

Whether you use the service console locally or through a remote connection, you must log in using a valid user name and password.

Commands Specific to ESX Server

Identifying Network Cards

The `findnic` command lets you send network traffic from a specified network adapter so you can observe the LEDs on the adapters and see which physical adapter is associated with that device name. The format of the command is

```
findnic <options> <nic-name> <local-ip> <remote-ip>
```

Option	Explanation
`-f`	Do a flood ping.
`-i <seconds>`	Send pings at specified interval.

Example:

```
findnic -f vmnic1 10.2.0.5 10.2.0.4
```

Binds VMkernel device `vmnic1` to IP address 10.2.0.5, then tries to flood ping the remote machine with the IP address 10.2.0.4.

For more information, see The VMkernel Network Card Locator on page 365.

Managing a VMware ESX Server File System

The `vmkfstools` command lets you create and manipulate files on SCSI disks managed by ESX Server.

Note: You must be logged in as the root user to run the `vmkfstools` command.

The format for the `vmkfstools` command, when specifying a SCSI device, is:

```
vmkfstools <options> <device_or_VMFS_volume>[:<file>]
```

where **<device_or_VMFS_volume>** specifies a SCSI device (a SCSI disk or a partition on a SCSI disk) being manipulated or a VMFS volume, and `<options>` specifies the operation to be performed.

If `<device_or_VMFS_volume>` is a SCSI device, then it is specified in a form such as:

```
vmhba1:2:0:3
```

`<device_or_VMFS_volume>` may also be a VMFS volume name, as set in the management interface or with the `vmkfstools --setfsname` command.

`<file>` is the name of a file stored in the VMFS volume on the specified device.

The format for the `vmkfstools` command, when specifying a VMFS volume or file, is:

```
vmkfstools <options> <path>
```

where `<path>` is an absolute path that names a directory or a file under the `/vmfs` directory.

For a detailed explanation on using this command and its options, see Using vmkfstools on page 229.

Automatically Mounting VMFS Volumes

VMFS volumes are automatically mounted in the `/vmfs` directory on the service console when the VMkernel is loaded as the computer boots.

Loading VMkernel Device Modules

The program `vmkload_mod` is used to load device driver and network shaper modules into the VMkernel. `vmkload_mod` can also be used to unload a module, list the loaded modules and list the available parameters for each module.

The format for the command is

```
vmkload_mod <options> <module-binary> <module-tag>
<parameters>
```

For more information, see VMkernel Module Loader on page 284.

Common Linux Commands Used on the Service Console

The service console runs a modified version of Linux, and many of the commands available on Linux or Unix are also available on the service console. This section summarizes the most commonly used commands. For more detailed information, see Getting Help for Service Console Commands on page 206 or consult a Linux reference book.

Manipulating Files

To navigate through the directory structure and manipulate files and directories, you must have proper permissions. In some areas of the file system, your abilities may be restricted when you are logged in as an ordinary user. You may need to log in as root, also known as the super user (`su`), to perform some tasks.

Command	Example and Explanation

`cd`	Change directories.
	
	`cd /home/user`
	Change to the directory `/home/user` (the home directory for a user with the user name `user`).
	
	`cd ..`
	Go up one level from the current directory.

`cp`	Copy a file.
	
	`cp oldfile newfile`
	Make a copy of the file `oldfile` in the current directory. The copy is named `newfile`.
	
	`cp oldfile /home/user`
	Make a copy of the file `oldfile` in the current directory. The copy also has the name `oldfile` and is in the directory `/home/user`.

`ln`	Create a link from one file or directory to another file or directory. `ln -s /bin/program prolink` Create a soft link (shortcut) from the existing file `/bin/program` to `prolink`. The link `prolink` is created in the current working directory. If you enter the command `prolink`, you run the program `/bin/program`.

Command	Example and Explanation

`ls`	List the files in the current directory.
	
	`ls -al`
	List all (`-a`) the files in the current directory in long (`-l`) format.
	
	`ls *.html`
	List files in the current directory that end with .html. The `*` is a wild-card character that represents any number of characters. The `?` is a wild-card character that represents a single character.
	
	`ls /home/user`
	List the files in the directory `/home/user`.

`mkdir`	Make a new directory.
	
	`mkdir newdir`
	Make a new directory called `newdir` beneath the current directory.
	
	`mkdir /home/newdir`
	Make a new directory called `newdir` beneath the `/home` directory.

`mv`	Move a file to a new directory or rename the file.
	
	`mv myfile /home/user`
	Move the file `myfile` from the current directory to the directory `/home/user`.
	
	`mv myfile yourfile`
	Rename the file `myfile`. The new filename is `yourfile`.

`pwd`	Show the path to the present working directory.
`rm`	Remove a file. `rm deadfile` Remove the file `deadfile` from the current directory.
`rmdir`	Remove a directory. `rmdir gone` Remove the directory `gone`, which exists beneath the current directory.

Finding and Viewing Files

Command	Example and Explanation
`cat`	Concatenate the contents of files and display the content on the screen. `cat /proc/vmware/mem` Display the contents of the file `/proc/vmware/mem`.

`find`	Find files under a specified directory that match conditions you specify.
	
	`find / -name myfil*`
	Find files in the root directory and all directories under it that have file names beginning with `myfil`. The `*` is a wild-card character that represents any number of characters. The `?` is a wild-card character that represents a single character.
	
	`find -name '*.vmx' -print -exec chown User2 {} \;`
	Find all files in this directory and all subdirectories that end with `.vmx`, display the names of all files that are found on the screen and, for each file (indicated by the curly braces — `{}`), change its owner to User2.
	The `-print` option is not necessary, but it is handy to track the progress of the `find` command. If you do not use `-print`, the `find` command is silent except for error messages from `find` or from `chown`.
	
	`find -name '*.vmx' -exec grep -il 'SOMETHING' {} \;`
	Find all files in this directory and all subdirectories that end with `.vmx` and look for the pattern SOMETHING in each of the files. The `-i` option to `grep` makes the search case-insensitive. The `-l` option to `grep` causes `grep` to display the names of the files that have SOMETHING in them. When a file is found that contains SOMETHING, this command displays the full path to the file from the current directory (for example, `./virtualmachines/Linux/RedHat71Test/redhat71.vmx`).

`grep`	Search for a specified text pattern in a specified directory or list of files and display the lines in which the pattern is found. `grep "log file" *` Search all the files in the current directory for the text string `log file`.

`less`	Display the contents of a specified file one screen at a time. Use the arrow keys to move up and down through the file.
	
	`less myfile`
	Display the contents of the file `myfile`.
	
	`grep "log file" * | less`
	Search all the files in the current directory for the text string `log file` and use `less` to display the results so you can scroll up and down through them.

Command	Example and Explanation

`more`	Display the contents of a specified file one screen at a time. Use the spacebar to move forward through the file a screen at a time; use the Enter key to move forward through the file one line at a time.
	
	`more myfile`
	Display the contents of the file `myfile`.
	
	`grep "log file" * | more`
	Search all the files in the current directory for the text string `log file` and use `more` to display the results so you can view them one screen at a time.

Managing the Computer and Its Users

The root user or super user (`su`) can run all of these commands. Some of the commands — generally, those that simply provide information — are available to other users, as well.

Command	Example and Explanation

`apropos`	Find commands with descriptions that include a specified word. Displays the name of the command and the first line of the description.
	
	`apropos file`
	Find commands with descriptions that include the word `file`.
	
	`apropos file | less`
	Find commands with descriptions that include the word `file` and use `less` to display the results so you can scroll up or down through them.

`du`	Display usage in kilobytes for contents of the current directory or for a specified file or directory. `du /bin` Show how much disk space is used by the `/bin` directory.
`vdf`	`vdf` is an ESX Server-customized version of the `df` command. Use `vdf` in place of the `df` command. `vdf` works with all the standard `df` options. Displays free space for all mounted file systems. The listing also shows the total space, amount of space used and percentage of space used for each file system.
`fdformat`	Do a floppy disk format. `fdformat /dev/fd0` Format a floppy disk in the first floppy disk drive.

Command	Example and Explanation
`groupadd`	Add a new group. `groupadd newgroup` Add a group named `newgroup` to the system.
`hostname`	Display the system's host name.
`ifconfig`	Display the network interface configuration information for devices used by the service console.
`insmod`	Install a loadable module into the running kernel. `insmod parport` Install the loadable module named `parport` into the running kernel.
`kill`	Kill a specified process. `kill 3456` Kill the process with a process ID of 3456. `kill -9` is the surest way to kill a process; however, use it only as a last resort since it will not save editor buffers.
`lsmod`	List all loaded modules.
`lspci`	List PCI devices available to the service console. `lspci -v` List PCI devices in verbose mode.
`mount`	Mount a specified storage device at a specified location in the file system. `mount /dev/fd0 /mount/floppy` Mount the first physical floppy drive so its contents are visible in the directory `/mount/floppy`. The directory `/mount/floppy` must already exist.
`passwd`	Change your password. `passwd user` Change the password for a user named `user`. You must be logged in as the root user (`su`) to change another user's password.
`ps`	Show names, process IDs and other information for running processes. `ps -ef` Show full (`-f`) information about every (`-e`) running process.

Command	Example and Explanation

`shutdown`	Shut down the computer.
	
	`shutdown -h 5`
	Completely halt (`-h`) the computer in 5 minutes.
	
	`shutdown -r now`
	Shut down and restart (`-r`) the computer immediately.

`umount`	Unmount a specified device. `umount /mount/floppy` Unmount the device currently mounted at `/mount/floppy`.
`useradd`	Add a new user to the system. `useradd newuser` Add a new user with a user name of `newuser` to the system.
`who`	Show the user names of all users logged in to the system.
`whoami`	Show what user name you are currently using on the system.

Setting File Permissions and Ownership

Files and directories on the service console can have read, write and execute permissions. Those permissions can be on or off for the owner of the file (generally, the user who created it), the specified group (generally, a group to which the creator belongs) and all other users on the system. Permissions are indicated for each file when you display a long directory listing, as seen in the following sample.

```
[User@vmwareserver win2000]$ ls -la
total 104
drwxr-xr-x    2 User     User         4096 Jul 17 11:15 .
drwxr-xr-x    5 User     User         4096 Jul 17 09:51 ..
-rw-------    1 User     User         8664 Jul 17 16:17 nvram
-rw-r--r--    1 User     User        77763 Jul 18 14:14 vmware.log
-rwxr-xr--    1 User     User         1307 Jul 17 11:20 win2000.vmx
```

Notice that in the top two lines of the directory listing, the first character is the letter `d`. That indicates the listing on the line is for a directory. The single dot at the end of the first line indicates this listing is for the current directory. The two dots at the end of the second line indicate this listing is for the parent of the current directory.

The first character in the last line is a `-`. This indicates that `win2000.vmx` is an ordinary file. The word `User` in the third column indicates the file is owned by a user

named User. The word `User` in the fourth column indicates the file's owner is a member of a group named User.

Permissions for the owner, the specified group and all other users are indicated in the first column: `-rwxr-xr--`. The owner's permissions are specified first: `rwx` (read, write and execute). Permissions for other members of the group User are `r-x` (read and execute). The final cluster of three characters (`r--`) indicates all other users have permission to read the file but not to write to it or execute it.

You can change permissions for a file using the `chmod` command, shown in the next table. One convenient way of specifying the permissions you want to set is by using a numerical shorthand.

Read = 4
Write = 2
Execute = 1

Combinations of these permissions are specified by adding the numbers for the permissions you want to set. For example, read and execute is 5. Read, write and execute is 7.

Permissions are specified in the same order as they are shown in the directory listing — owner, group, all other users.

Command	Example and Explanation

`chmod`	Change mode (permissions) for a specified file, group of files or directory.
	
	`chmod 755 *.vmx`
	Set permissions on all files in the current directory that end with `.vmx` to be `-rwxr-xr-x`.
	
	`chmod 660 nvram`
	Set permissions on the file nvram in the current directory to be `-rw-rw----`.

`chown`	Change the owner of a specified file. You can change the owner and the group for a file at the same time.
	
	`chown User2 win2000.vmx`
	Change the owner of the file `win2000.vmx` to User2.
	
	`chown User2:VMUsers win2000.vmx`
	Change the owner of the file `win2000.vmx` to User2 and change the group to VMUsers.

Command	Example and Explanation
`chgrp`	Change the group for a specified file. `chgrp VMUsers win2000.vmx` Change the group for the file `win2000.vmx` to VMUsers.

Switching User Names

Command	Example and Explanation
`su`	Switch user. By default, this allows you to log in as the root user if you know the root user's password. You can also use the command to log in as any other user if you know the appropriate user name and password. Enter the command, then enter the password when prompted. `su User2` Log in as User2.
`exit`	Log out. If you have used `su` to log in as a different user, this returns you to your previous user name.

The proc File System

The `proc` file system is a set of directories, beginning with `/proc`, that exist in memory while ESX Server is running. The contents of these directories are not stored on disk.

The `/proc/vmware` directory contains information specific to the running of the ESX Server virtualization layer in virtual machines. You can use the `cat` command to check status and use the `echo` command to write values to certain files in the `proc` file system to change the configuration of ESX Server.

Note: Most of this information is also available through the VMware Management Interface, and we strongly recommend that you obtain and set information through this management interface. Do not add or change any options in this directory unless you are instructed to by VMware support to solve an issue with ESX Server.

Caution: Do not use the `proc` interface to set any values other than those mentioned in these sections:

- Managing CPU Resources from the Service Console on page 395
- Managing Memory Resources from the Service Console on page 411
- Manual NUMA Optimizations on page 420
- Managing Disk Bandwidth from the Management Interface on page 433
- Managing Disk Bandwidth from the Service Console on page 434

Note: The contents and format of the `/proc/vmware` directory may change between releases of ESX Server.

/proc/vmware Entry	Description
chipset	State of interrupt controllers.
config	Advanced ESX Server parameters available through the VMware Management Interface.
debug	Debugging information.
filters	Network traffic shaping. See Traffic Shaping with nfshaper on page 430.
interrupts	Used, together with chipset, to determine the state of interrupt controllers.
log	VMkernel log output.
loglevels	Amount of debug logging.
mem	Memory parameters. See Memory Resource Management on page 403.
migration	Reserved for future use.
net	Configuration and statistics for virtual NICs and bond devices. See Binding Physical Adapters on page 373.
pci	State of PCI adapters in the system (what they are and how they're partitioned).
procstats	Statistics for the `/proc/vmware` directory.
pshare	Page sharing statistics for memory resource management. See Sharing Memory Across Virtual Machines on page 408 and Memory Sharing on page 425.
rpcstats	Statistics on remote procedure calls (RPCs).
sched	Scheduler statistics on memory and CPU.
scsi	Information on SCSI devices and mappings between storage controllers and virtual machines.
shrdev	Statistics on shared devices.
stats	Counts of various low-level events in ESX Server.
swap	Swap statistics.
thermmon	Thermal monitoring information for each Pentium® 4 processor.
timers	State of ESX Server internal timed event scheduler.
uptime	ESX Server uptime.
vm	Statistics for individual virtual machines by VMID.
vmkperf	Statistics on ESX Server performance.
watchpoints	Statistics for debugging.

Getting Help for Service Console Commands

Detailed usage notes for most service console commands are available as manual — or man — files. To view the manual file — or man page — for a particular command, use the `man` command followed by the name of the command for which you want to see information.

Command	Example and Explanation

`man`	Displays the manual page for a specified command. Press the spacebar to go to the next screen of text. Press `q` to exit from the display when you are finished.
	
	`man cat`
	Display the manual page for the command `cat`.
	
	`man cat | less`
	Display the manual page for the command `cat`, and use `less` to display the results so you can scroll up and down through them.

Authentication and Security Features

This section contains the following:

- Authenticating Users on page 207
- Default Permissions on page 209
- TCP/IP Ports for Management Access on page 209

There are three key aspects to security with VMware ESX Server.

- VMware ESX Server authenticates all remote users who connect to a server using the VMware Management Interface or the VMware Remote Console.
- Security for network traffic to and from the server depends on the security settings in the server configuration.
- Three or more TCP/IP ports are used for access, depending on the security settings in your ESX Server configuration.

  Depending on your remote access requirements, you may need to configure your firewall to allow access on one or more of these ports. For details on which ports are used, see TCP/IP Ports for Management Access on page 209.

Authenticating Users

VMware ESX Server uses Pluggable Authentication Modules (PAM) for user authentication in the remote console and the VMware Management Interface. The default installation of ESX Server uses `/etc/passwd` authentication, just as Linux does, but it can easily be configured to use LDAP, NIS, Kerberos or another distributed authentication mechanism.

The PAM configuration is in `/etc/pam.d/vmware-authd`.

Every time a connection is made to the server running ESX Server, the `inetd` process runs an instance of the VMware authentication daemon (`vmware-authd`). The `vmware-authd` process requests a user name and password, then hands them off to PAM, which performs the authentication.

Once a user is authenticated, `vmware-authd` accepts a path name to a virtual machine configuration file. Access to the configuration file is restricted in the following ways:

- The user must have **read** access to the configuration file to see and control the virtual machine in the VMware Management Interface and to view the virtual machine details pages.

- The user must have **read** access to the configuration file to use the local console on the service console or to connect to the virtual machine with the VMware Perl API.
- The user must have **read** and **execute** access to the configuration file to connect to and control (start, stop, reset or suspend) a virtual machine in a remote console, with the VMware Perl API or with the management interface.
- The user must have **read** and **write** access to the configuration file to change the configuration using the Configure VM page in the management interface.

Note: If you have users with **list** access, but not **read** access, they may encounter errors in the VMware Management Interface.

If a `vmware` process is not running for the configuration file you are trying to use, `vmware-authd` examines `/etc/vmware/vm-list`, the file where you register your virtual machines. If the configuration file is listed in `vm-list`, `vmware-authd` (not necessarily the user who is currently authenticated) starts VMware ESX Server as owner of this configuration file.

Registered virtual machines (those listed in `/etc/vmware/vm-list`) also appear in the VMware Management Interface. The virtual machines you see on the Status Monitor page must be listed in `vm-list`, and you must have read access to their configuration files.

The `vmware-authd` process exits as soon as a connection to a `vmware` process is established. Each `vmware` process shuts down automatically after the last user disconnects.

Using Your Own Security Certificates when Securing Your Remote Sessions
The username, password and network packets sent to ESX Server over a network connection when using the VMware Remote Console or the VMware Management Interface are encrypted in ESX Server by default when you choose Medium or High security settings for the server.

With SSL enabled, security certificates are created by ESX Server and stored on the server. However, the certificates used to secure your management interface sessions are not signed by a trusted certificate authority; therefore they do not provide authentication. If you intend to use encrypted remote connections externally, you should consider purchasing a certificate from a trusted certificate authority.

If you prefer, you can use your own security certificate for your SSL connections.

The VMware Management Interface certificate must be placed in `/etc/vmware-mui/ssl`. The management interface certificate consists of 2 files: the certificate

itself (`mui.crt`) and the private key file (`mui.key`). The private key file should be readable only by the root user.

When you upgrade the management interface, the certificate remains in place and, in case you removed the management interface, the directory is not removed from the service console.

Default Permissions

When you create a virtual machine with VMware ESX Server, its configuration file is registered with the following default permissions, based on the user accessing it:

- Read, execute and write — for the user who created the configuration file (the owner)
- Read and execute — for the owner's group
- Read — for users other than the owner or a member of the owner's group

TCP/IP Ports for Management Access

The TCP/IP ports available for management access to your ESX Server machine vary, depending on the security settings you choose for the server. If you need to manage ESX Server machines from outside a firewall, you may need to reconfigure the firewall to allow access on the appropriate ports. The lists below show which ports are available when you use each of the standard security settings.

The key ports for use of the VMware Management Interface and the VMware Remote Console are the HTTP or HTTPS port and the port used by `vmware-authd`. Use of other ports is optional.

High Security

- 443 – HTTPS, used by the VMware Management Interface
- 902 – `vmware-authd`, used when you connect with the remote console
- 22 – SSH, used for a secure shell connection to the service console

Medium Security

- 443 – HTTPS, used by the VMware Management Interface
- 902 – `vmware-authd`, used when you connect with the remote console
- 22 – SSH, used for a secure shell connection to the service console
- 23 – Telnet, used for an insecure shell connection to the service console
- 21 – FTP, used for transferring files to and from other machines

- 111 – `portmap`, used by the NFS client when mounting a drive on a remote machine

Low Security

- 80 – HTTP, used by the VMware Management Interface
- 902 – `vmware-authd`, used when you connect with the remote console
- 22 – SSH, used for a secure shell connection to the service console
- 23 – Telnet, used for an insecure shell connection to the service console
- 21 – FTP, used for transferring files to and from other machines
- 111 – `portmap`, used by the NFS client when mounting a drive on a remote machine

Using Devices With ESX Server

In this section, we discuss any considerations in using devices with ESX Server.

Supporting Generic Tape and Media Changers

In order for the guest operating system to see and control the media changer directly, you must be sure that the SCSI ID in the target raw device's configuration file matches with the SCSI ID that ESX Server sees for that device. You can check the SCSI ID seen by ESX Server, by viewing the output of the various files `/proc/vmware/scsi/vmhba<x>/<y>:<z>`, where `<x>` is the HBA ID assigned by ESX Server, `<y>` is the SCSI target ID, and `<z>` is the SCSI LUN ID.

For more information on adding a tape device to a virtual machine, see Adding a Tape Drive to a Virtual Machine on page 136.

Editing the vmware-device.map.local File

The `/etc/vmware/vmware-device.map` file contains a list of devices supported by ESX Server. This release includes support for a local version of this file, `/etc/vmware/vmware-device.map.local`.

Modify the `vmware-device.map.local` to select different device drivers. This file is not modified during an ESX Server upgrade, preserving your customizations. The `vmware-device.map.local` is read when the VMkernel is loaded:

- Any changes to the `vmware-device.map.local` file require a reboot, or at least an unload/reload of the VMkernel to take effect.
- Entries in the `vmware-device.map.local` files are used in addition to the entries in the `vmware-device.map` file. The `vmware-device.map.local` file does not need to mirror the `vmware-device.map` file.
- Any `vmware-device.map.local` file entries that correspond to the `vmware-device.map` file entries supersede the `vmware-device.map` file entries.

Finding Disk Controllers

You can use the `vmkpcidivy` command to list physical disk controllers recognized by ESX Server and the device names linked to them in the Service Console. Physical disk controllers may be SCSI or block devices, such as disk array controllers.

The `-query` option of `vmkpcidivy` reports various ESX Server configuration details. For example, you can display all disk controllers and their associated device names with the `vmhba_devs` query:

```
$ vmkpcidivy -q vmhba_devs
vmhba0:0:0 /dev/ida/c0d0
vmhba1:0:0 /dev/sda
vmhba1:0:1 /dev/sdb
```

You can also find the device name linked to a specific controller with the singular `vmhba_dev` query:

```
$ vmkpcidivy -q vmhba_dev vmhba0:0:0
/dev/ida/c0d0
```

The `vmhba_dev` query accepts one or more controller names as arguments.

Enabling Users to View Virtual Machines Through the VMware Remote Console

The default security setting for ESX Server is that users must have read (**r**) and execute (**x**) access permissions to connect a remote console to a virtual machine. However, if you want to allow access to users with only read permissions, you can do so with the following global configuration setting:

```
authd.policy.allowRCForRead = "TRUE"
```

Add the preceding line to the `/etc/vmware/config` file. This setting allows users with only read permissions to connect to a virtual machine through the remote console.

Note: This configuration setting affects all virtual machines on an ESX Server machine. You cannot change this setting for individual virtual machines.

CHAPTER 6

Administering ESX Server

ESX Server configuration can be viewed and modified through the VMware Management Interface. This section provides an overview of the configuration modification options.

- Modifying VMware ESX Server on page 216
- Seeing How Memory Is Utilized on page 253
- Configuring Startup and Shutdown Options for Virtual Machines on page 257
- Rebooting or Shutting Down the Server on page 263

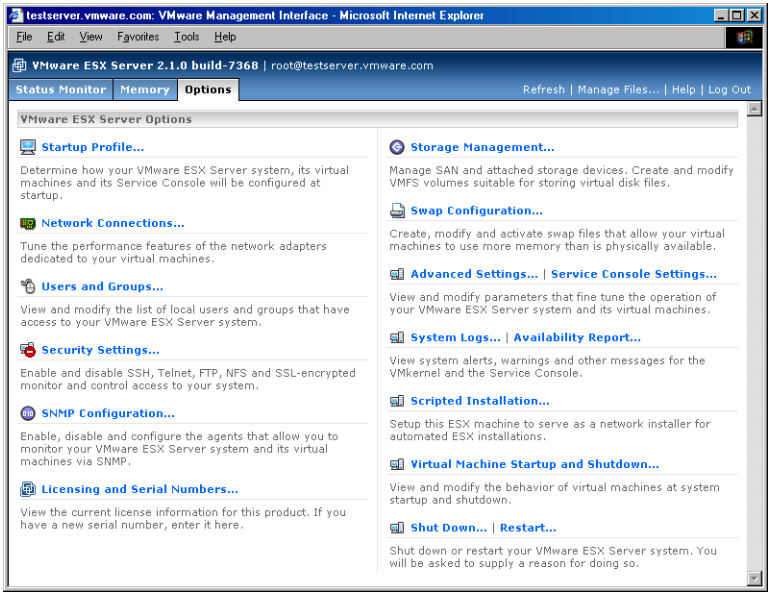
Modifying VMware ESX Server

To modify the ESX Server configuration:

1. Log in to the VMware Management Interface as root.

   The Status Monitor page appears.

2. Click the **Options** tab. The Options page appears.


testserver.vmware.com: VMware Management Interface - Microsoft Internet Explorer
File Edit View Favorites Tools Help
VMware ESX Server 2.1.0 build-7368 | root@testserver.vmware.com
Status Monitor
Memory
Options
Refresh | Manage Files... | Help | Log Out
VMware ESX Server Options
Startup Profile...
Determine how your VMware ESX Server system, its virtual machines and its Service Console will be configured at startup.
Network Connections...
Tune the performance features of the network adapters dedicated to your virtual machines.
Users and Groups...
View and modify the list of local users and groups that have access to your VMware ESX Server system.
Security Settings...
Enable and disable SSH, Telnet, FTP, NFS and SSL-encrypted monitor and control access to your system.
SNMP Configuration...
Enable, disable and configure the agents that allow you to monitor your VMware ESX Server system and its virtual machines via SNMP.
Licensing and Serial Numbers...
View the current license information for this product. If you have a new serial number, enter it here.
Storage Management...
Manage SAN and attached storage devices. Create and modify VMFS volumes suitable for storing virtual disk files.
Swap Configuration...
Create, modify and activate swap files that allow your virtual machines to use more memory than is physically available.
Advanced Settings... | Service Console Settings...
View and modify parameters that fine tune the operation of your VMware ESX Server system and its virtual machines.
System Logs... | Availability Report...
View system alerts, warnings and other messages for the VMkernel and the Service Console.
Scripted Installation...
Setup this ESX machine to serve as a network installer for automated ESX installations.
Virtual Machine Startup and Shutdown...
View and modify the behavior of virtual machines at system startup and shutdown.
Shut Down... | Restart...
Shut down or restart your VMware ESX Server system. You will be asked to supply a reason for doing so.

   Click the link for the desired server setting.

3. Make your changes.

   Click through the links and options displayed on the screen. The settings you can change and activities you can perform include:

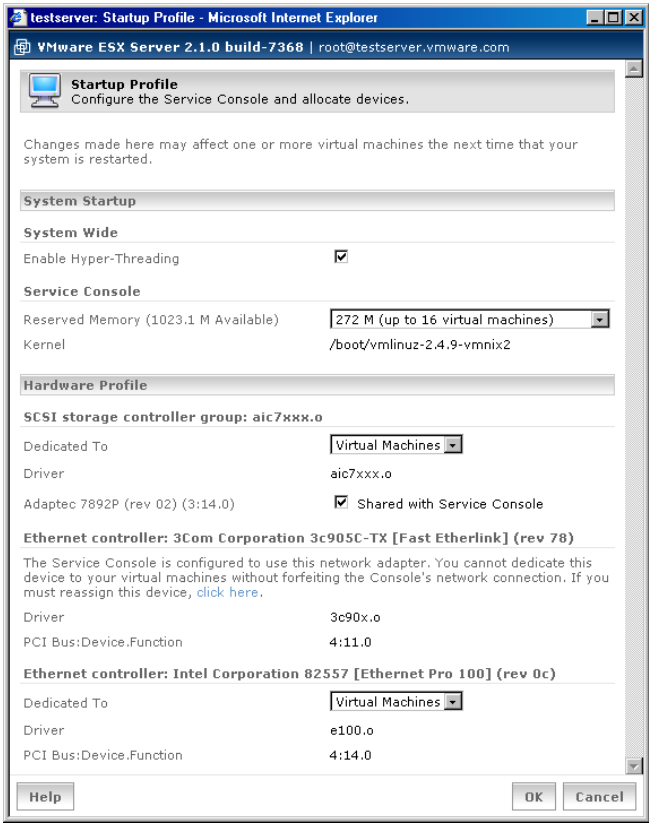
   - Updating the Startup Profile on page 218
   - Changing Network Connections on page 219
   - Changing Users and Groups on page 224
   - Configuring Security Settings on page 229
   - Configuring the SNMP Agent on page 231
   - Viewing the License and Changing Serial Numbers on page 232

- Configuring Storage Area Networks on page 232
- Adapter Bindings on page 238
- Viewing Failover Paths Connections on page 239
- Configuring a Swap File on page 241
- Changing Advanced Settings on page 242
- Configuring the Service Console on page 243
- Viewing System Logs and Reports on page 246

Refer to the *VMware ESX Server Installation Guide* for additional information about server configuration during installation.

Updating the Startup Profile

Use the **Startup Profiles** option to create and modify ESX Server boot configurations. For each configuration, you can specify how you wish to allocate your devices: to the virtual machines, to the service console or shared between them.


testserver: Startup Profile - Microsoft Internet Explorer
VMware ESX Server 2.1.0 build-7368 | root@testserver.vmware.com
Startup Profile
Configure the Service Console and allocate devices.
Changes made here may affect one or more virtual machines the next time that your system is restarted.
System Startup
System Wide
Enable Hyper-Threading
Service Console
Reserved Memory (1023.1 M Available)
272 M (up to 16 virtual machines)
Kernel
/boot/vmlinuz-2.4.9-vmnix2
Hardware Profile
SCSI storage controller group: aic7xxx.o
Dedicated To
Virtual Machines
Driver
aic7xxx.o
Adaptec 7892P (rev 02) (3:14.0)
Shared with Service Console
Ethernet controller: 3Com Corporation 3c905C-TX [Fast Etherlink] (rev 78)
The Service Console is configured to use this network adapter. You cannot dedicate this device to your virtual machines without forfeiting the Console's network connection. If you must reassign this device, click here.
Driver
3c90x.o
PCI Bus:Device.Function
4:11.0
Ethernet controller: Intel Corporation 82557 [Ethernet Pro 100] (rev 0c)
Dedicated To
Virtual Machines
Driver
e100.o
PCI Bus:Device.Function
4:14.0
Help
OK
Cancel

For information about changing the startup profile, see the *VMware ESX Server Installation Guide*.

If you add new hardware to your ESX Server system, such as extra SCSI controllers or network adapters, you can specify here whether to allocate the new hardware to the `vmkernel` and virtual machines, or allocate it to the service console.

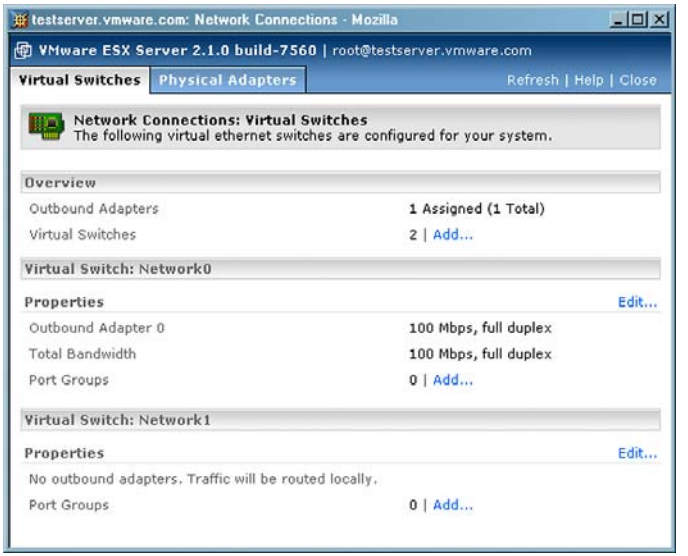
You also enable Hyper-Threading for your server with the startup profile. Hyper-Threading allows ESX Server to operate with two logical CPUs for each physical CPU you have installed in your system. Select the **Enable Hyper-Threading** option to

enable this feature. For more information on Hyper-Threading, see Using Hyper-Threading on page 393.

If you make any changes to the startup profile, you must reboot the server in order for your changes to take effect.

Changing Network Connections

Use the **Network Connections** option to configure the network connections. This option allows you to create new virtual switches or edit existing switches.



Creating a New Virtual Switch

1. Log in to the VMware Management Interface as root. The Status Monitor page appears.
2. Click the **Options** tab, then click the **Network Connections** tab. The Create Virtual Switch window opens and displays configuration options for the new switch.
3. Enter a name for the virtual switch in the **Network Label** field. The Network Labels feature allows you to specify a network label for switches and port groups that are used by virtual machines.
4. Bind Outbound Adapters lists all available adapters. Select an adapter to assign it to the new switch.

5. Other Outbound Adapters lists the adapters currently assigned to other switches. Select an adapter to reassign it to the new switch.
6. When you are finished selecting physical adapters, click **Create Switch**. This creates the new virtual switch and closes the window.

Editing an Existing Virtual Switch

1. To edit an existing virtual switch and its adapters, click **Edit**. The Edit Virtual Switch window opens and displays existing configuration and adapter settings for the switch.
2. Edit the network label of the switch in the **Network Label** field. The Network Labels feature allows you to specify a network label for switches and port groups that are used by virtual machines.

   Caution: If virtual machines are configured to use the switch and you change the name of the label, the virtual machines will not power on.
3. Bind Outbound Adapters lists all available adapters. Select an adapter to assign it to the switch.
4. To route network traffic locally, deselect all of the adapters and click **OK**. An internal adapter is created for the virtual switch. If you chose this configuration, a notification message appears and displays "No outbound adapters. Traffic routed locally."
5. Under Other Outbound Adapters, Bind Unassigned Adapters lists any unassigned adapters. Select an adapter to assign it to the switch. You can transfer any listed adapters from other switches to the virtual switch you are configuring.
6. When you are finished selecting physical adapters, click **OK** to save the new switch configuration and close the window.
7. To remove the switch, click **Remove Switch**. This removes the virtual switch and does not save any configuration changes made to the edit page.

Creating Port Groups

Port groups are extensions of networks, using Virtual Local Area Networks (VLANs). VLANs allow configured networks to communicate securely among themselves as if connected to a common isolated physical network. To create a port group, there must be an existing network configured.

1. Log in to the VMware Management Interface as root. The Status Monitor page appears.

2. Click the **Options** tab, then click the **Network Connections** tab. The Virtual Switches window opens.
3. To create a port group for a switch, click **Add** next to Port Groups. The Create Port Groups window opens and displays configuration options for a port group.
4. Enter a name for the port group in the **Port Group Label** field.
5. In the **VLAN ID** field, enter a number between 1 and 4095.
6. Click **Create Port Group**. This creates the new port group and closes the window.

Disabling vmkernel VLAN Tagging

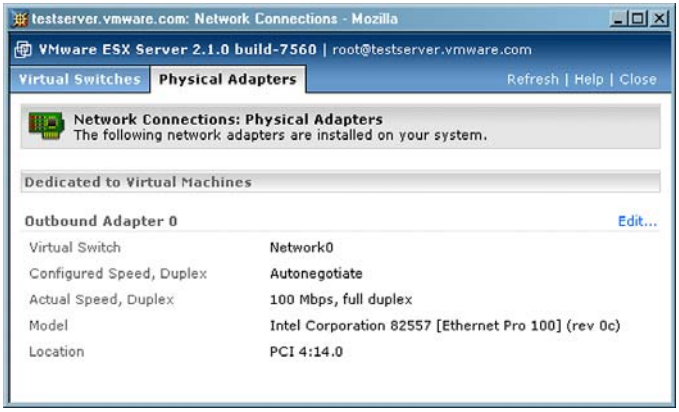
When Virtual Local Area Networks (VLANs) are created within your ESX Server, the vmkernel, by default, manages the VLAN processing of Ethernet frames. If you do not want the vmkernel to manage VLAN processing, you can configure the vmkernel to pass all Ethernet frames between guest operating systems and the outside network.

To change your VLAN processing settings:

1. From the **Options** tab, select **Advanced Settings**. The Advanced Settings page appears and displays a list of configuration parameters.
2. Locate the parameter: `Net.VlanTrunking`.
3. Click the value for the parameter. The Modify VMkernel Parameter window opens.
4. In the **Value** entry field, enter `1` (one) to enable the parameter or `0` (zero) to disable the parameter.
5. Click **OK** to close the window and save the setting.

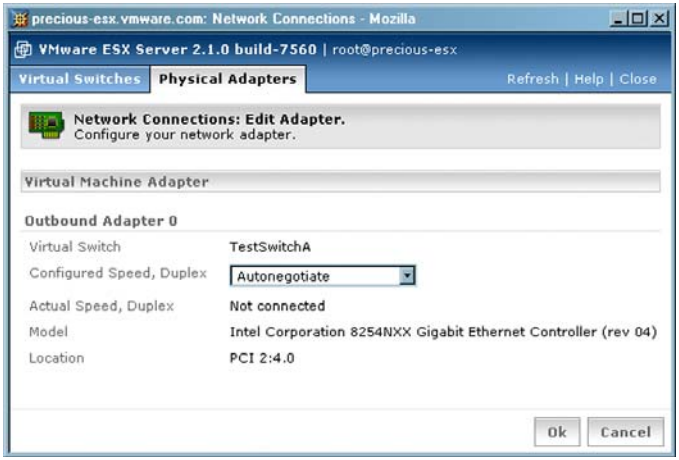
Configuring Physical Adapters

Use the Network Connections option to view and configure the physical adapters assigned to the virtual machines. This option allows you to change the speed and duplex settings of the adapters.



Configuring Network Speed and Duplex Settings

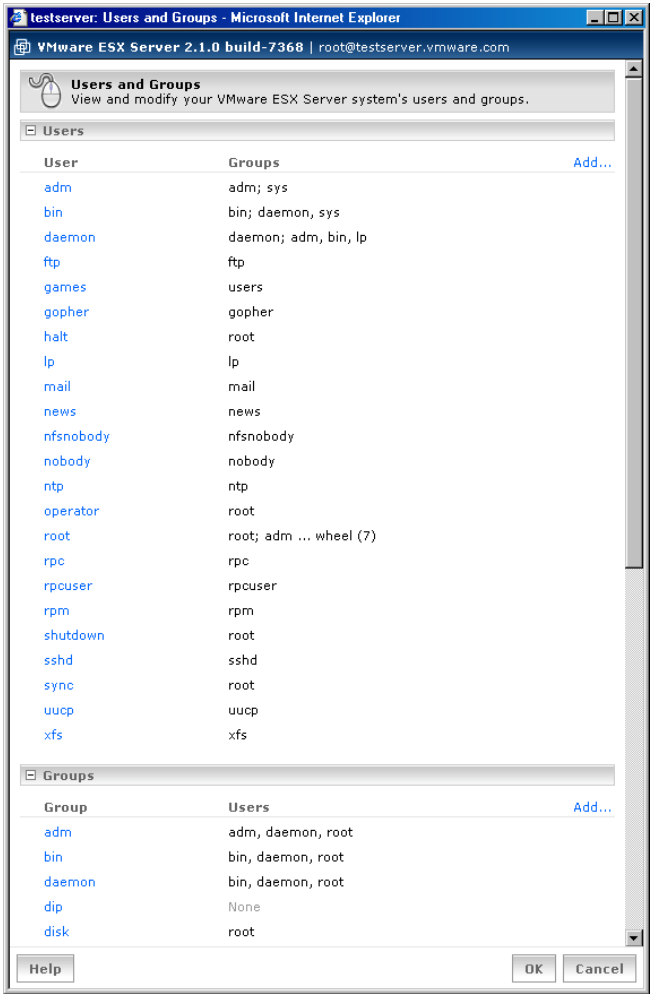
When you use the VMware Management Interface to configure network settings for the Ethernet adapters assigned to virtual machines, you see the actual speed and duplex settings for each adapter. If the adapter is configured to Autonegotiate, these settings are automatically negotiated by the adapter. If these settings are not appropriate, click **Edit** next to the physical adapter you want to change.



From the Physical Adapters details page, choose the settings you want from the Configured Speed, Duplex pull-down list. Click **OK** to save the updated configured speed.

Changing Users and Groups

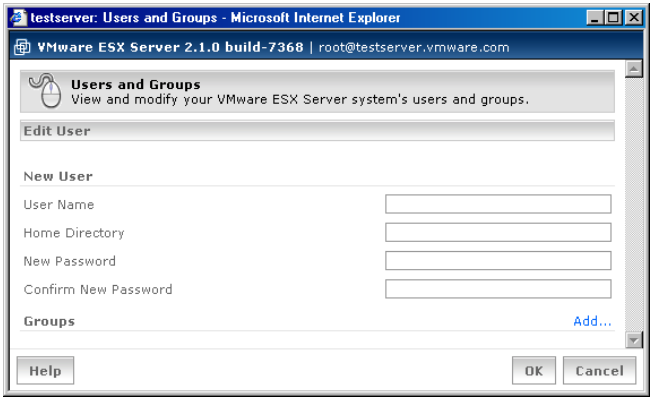
Use the **Users and Groups** option to add, modify and remove ESX Server users and groups. This dialog box lists each user, the groups to which the user belongs, each group and the users that are part of each group.



Adding Users and Groups

To add a new user, complete the following steps.

1. Expand the **Users** list. Click the + (plus) sign next to **Users**, then click **Add**. The Edit Users and Groups page appears.

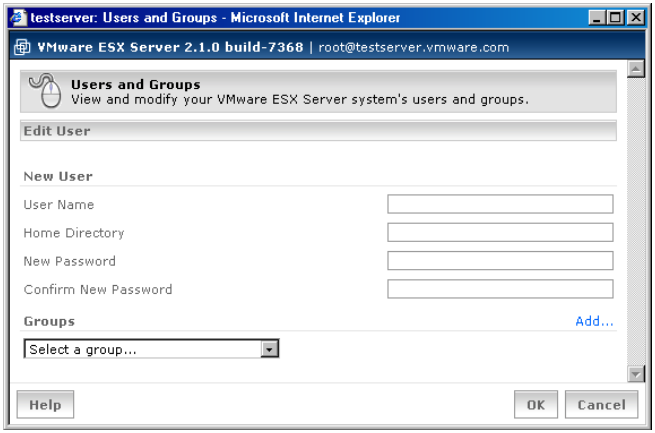


2. In the **User Name** field, type the name of the new user.
3. In the **Home Directory** field, type the name of the default directory for the user in the service console.
4. In the **New Password** field, type the password for the user's account.
5. In the **Confirm New Password** field, type the same password.
6. To add the user to one or more groups, click **Add**, then select a group from the list. Repeat this step for each group to which you want to add the user.

   Note: If you do not want the user to be part of a group, click **Remove** next to the group name.
7. When you are finished setting up the new user account, click **OK** to save the new user information and close the window.

To add a new group, complete the following steps.

1. Expand the **Groups** list. Click the + (plus) sign next to **Groups**, then click **Add**. The Edit Users and Groups page appears.



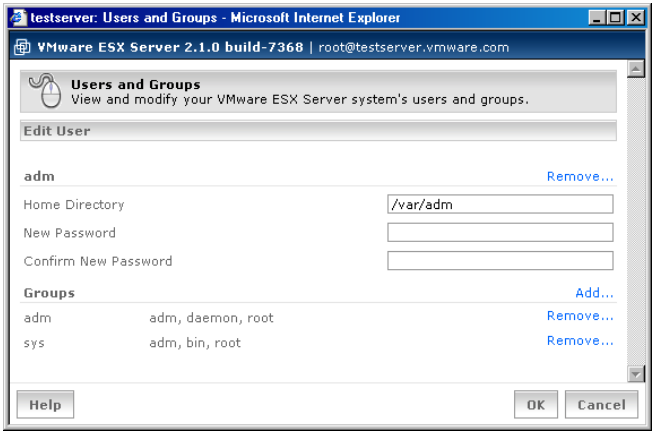
2. In the **Group Name** field, type the name of the new group.
3. To add one or more users to the group, click **Add**, then select a user from the list. Repeat this step for each user you want to add to the group.

   Note: If you want to remove a user from the group, click **Remove** next to the user name.
4. When you are finished setting up the new group, click **OK** to save the new group information and close the window.

Editing and Removing Users and Groups

To change information for or remove a user, complete the following steps.

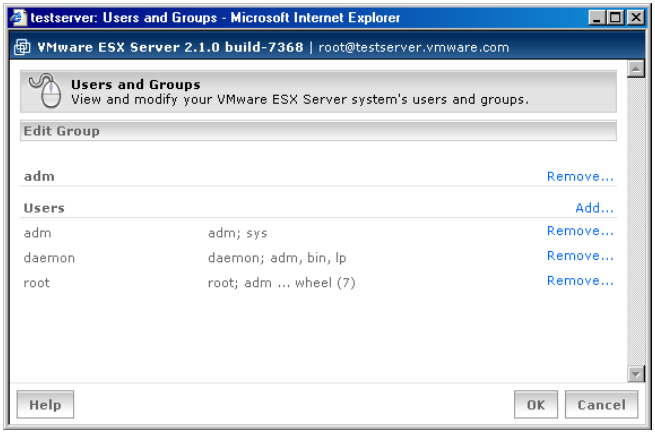
1. Expand the **Users** list. Click the + (plus) sign next to **Users**, then click the user you want to edit or remove. The Edit Users and Groups page appears.



2. Do any of the following:
   - To change the user's home directory, in the **Home Directory** field, type the name of the default directory for the user in the service console.
   - To change the user's password, in the **New Password** field, type the password for the user's account; in the **Confirm New Password** field, type the same password.
   - To add the user to one or more groups, click **Add**, then select a group from the list. Repeat this step for each group to which you want to add the user.
   - To remove the user from any group, click **Remove** next to the group name.
   - To remove the user completely, click **Remove** next to the user's name. You are prompted to confirm you want to remove the user. The window closes automatically.
3. When you are finished changing the user account, click **OK** to save your changes and close the window.

To change information for or remove a group, complete the following steps.

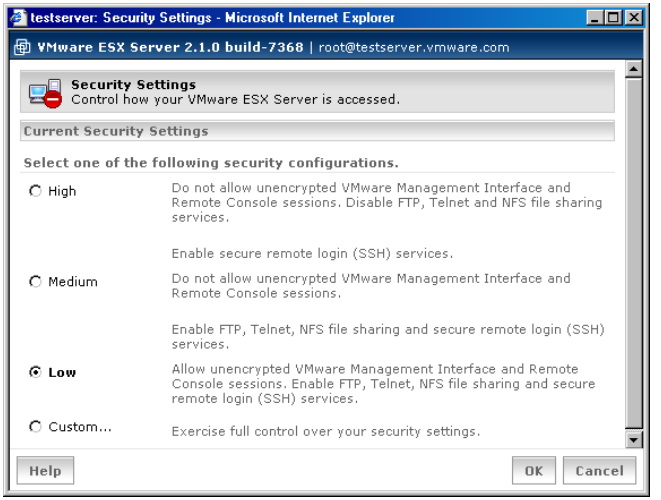
1. Expand the **Groups** list. Click the + (plus) sign next to **Groups**, then click the group you want to edit or remove. The Edit Users and Groups page appears.



2. Do any of the following:
   - To add one or more users to the group, click **Add**, then select a user from the list. Repeat this step for each user you want to add to the group.
   - To remove any user from the group, click **Remove** next to the user name.
   - To remove the group completely, click **Remove** next to the group's name. You are prompted to confirm you want to remove the group. The window closes automatically.
3. When you are finished changing the group, click **OK** to save your changes and close the window.

Configuring Security Settings

Use the **Security Settings** option to configure ESX Server security properties. You can set up unencrypted Web access and enable SSH, telnet and FTP access to the server and enable NFS file sharing.


testserver: Security Settings - Microsoft Internet Explorer
VMware ESX Server 2.1.0 build-7368 | root@testserver.vmware.com
Security Settings
Control how your VMware ESX Server is accessed.
Current Security Settings
Select one of the following security configurations.
High
Do not allow unencrypted VMware Management Interface and Remote Console sessions. Disable FTP, Telnet and NFS file sharing services.
Enable secure remote login (SSH) services.
Medium
Do not allow unencrypted VMware Management Interface and Remote Console sessions.
Enable FTP, Telnet, NFS file sharing and secure remote login (SSH) services.
Low
Allow unencrypted VMware Management Interface and Remote Console sessions. Enable FTP, Telnet, NFS file sharing and secure remote login (SSH) services.
Custom...
Exercise full control over your security settings.
Help
OK
Cancel

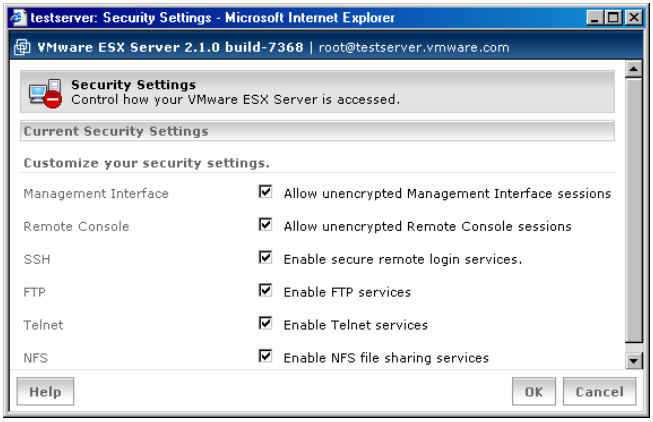
By default, the server is set to **High** security, which does not allow unencrypted VMware Management Interface and Remote Console sessions. High security enables SSH access for secure remote login sessions, but it also disables FTP, Telnet and NFS file sharing services.

Choose **Medium** security to disallow unencrypted VMware Management Interface and Remote Console sessions. Normal access enables FTP, Telnet, NFS file sharing and secure remote login (SSH) services.

Choose **Low** security to allow unencrypted VMware Management Interface and VMware Remote Console sessions, FTP, Telnet, NFS file sharing and secure remote login (SSH) services.

Using Custom Security Settings

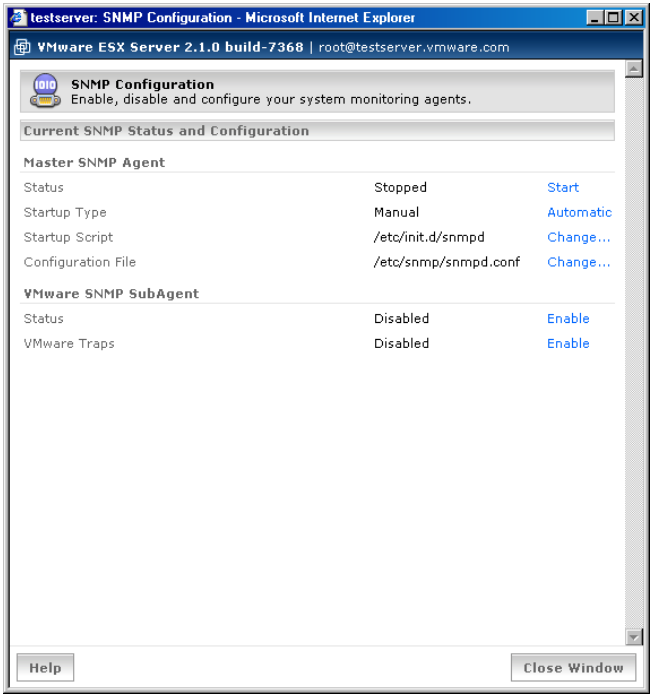
By customizing your security settings, you can enable or disable various settings that provide access to the server, such as unencrypted Web access, SSH, telnet, FTP and NFS file sharing. To customize your security settings, click **Custom**. The Security Settings dialog box changes to allow you to choose specific security settings.



Check the appropriate boxes for items you want to enable, then click **OK**.

Configuring the SNMP Agent

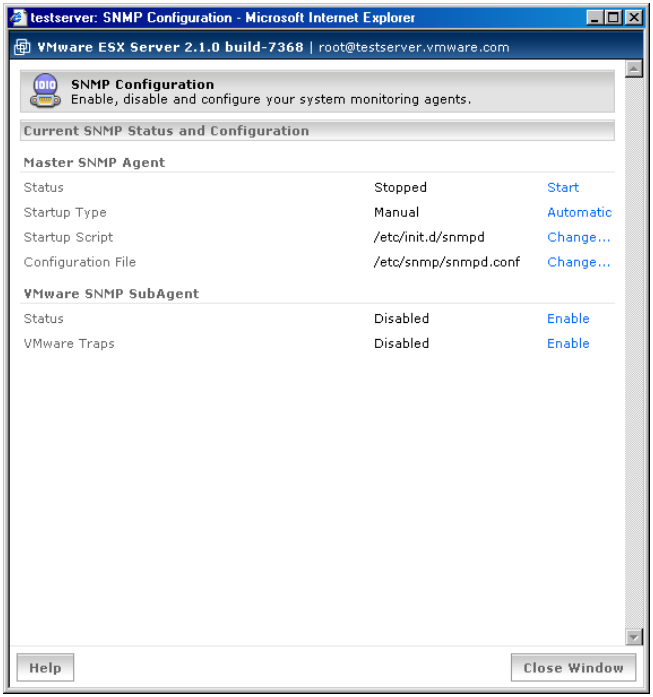
Use the **SNMP Configuration** option to configure the ESX Server SNMP agent and sub-agent, allowing you to monitor the health of the server and of virtual machines running on the server.


testserver: SNMP Configuration - Microsoft Internet Explorer
VMware ESX Server 2.1.0 build-7368 | root@testserver.vmware.com
SNMP Configuration
Enable, disable and configure your system monitoring agents.
Current SNMP Status and Configuration
Master SNMP Agent
Status Stopped Start
Startup Type Manual Automatic
Startup Script /etc/init.d/snmpd Change...
Configuration File /etc/snmp/snmpd.conf Change...
VMware SNMP SubAgent
Status Disabled Enable
VMware Traps Disabled Enable
Help
Close Window

To configure the SNMP agents, see Configuring the ESX Server Agent through the VMware Management Interface on page 234. For more complete information about SNMP, see Using SNMP with ESX Server on page 230.

Viewing the License and Changing Serial Numbers

Use the **Licensing and Serial Numbers** option to view the current license information for this product. If you have a new serial number for either ESX Server or VMware Virtual SMP for ESX Server, you may enter them here.



Note: If you enter a new serial number for a license that changes the maximum number of processors allowed on the server, you are prompted to reboot the server for the new license to take effect.

Configuring Storage Area Networks

Use the **Storage Management** option to manage your storage area network and attached storage devices for your ESX Server system and its virtual machines.

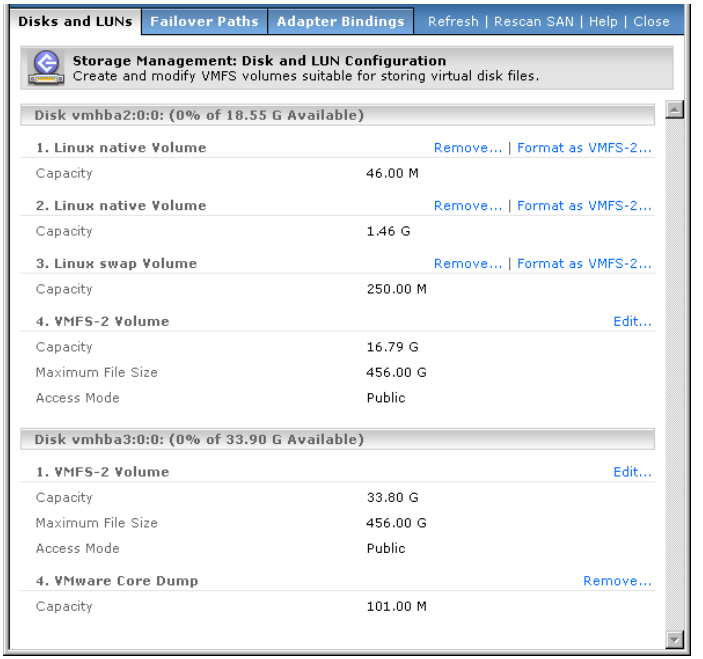
Because the disks on the SANs can potentially be accessed by multiple ESX Server computers, there are some configuration issues that are unique to SANs.

For more information about SANs, see Using Storage Area Networks with ESX Server on page 277.

Note: Be sure that only one ESX Server system has access to the SAN while you are using the VMware Management Interface to configure it by formatting the VMFS-2 volumes. After you have finished the configuration, be sure that all partitions on the shared disk are set for public or shared access for access by multiple ESX Servers (see VMFS Accessibility on page 257).

Configuring Storage: Disk Partitions and File Systems

The Disks and LUNS window allows you to view and modify the partitions and file systems on your disks. Create disk partitions that use the VMFS file system, suitable for storing disks for virtual machines. You can also edit, label and remove existing partitions. When you edit a VMFS partition, you can change the volume label, maximum file size, access mode and whether you want to span the partition.



Creating a Disk Partition

You can use any existing free space on your VMFS volumes to create new disk partitions. For background on how SCSI devices are identified, see Determining SCSI Target IDs on page 273.

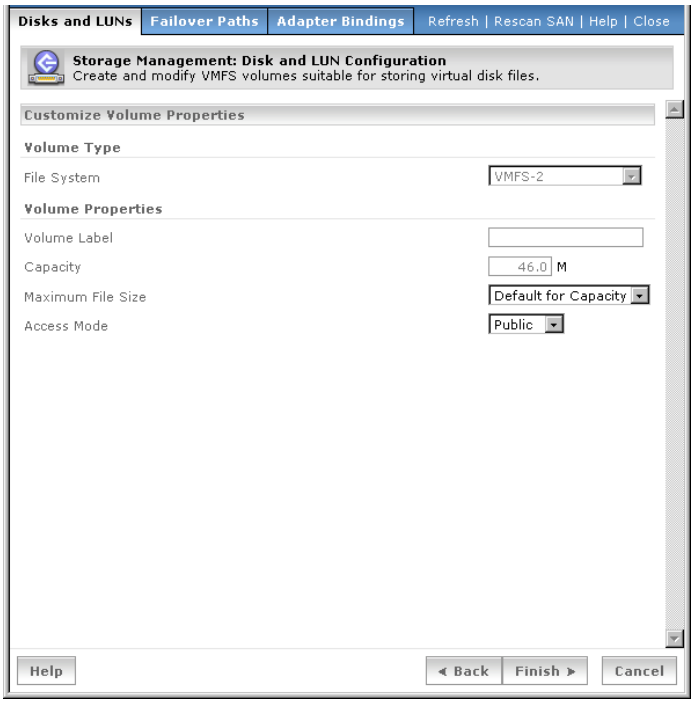
Note: You cannot change any partitions set up when you installed ESX Server. These include any volumes with a Linux file system or that are used for Linux swap space.

If a core dump file does not exist on the disk, you are offered to create one. Creating a new volume consumes all the free space remaining on a disk. ESX Server determines the optimum setting for the maximum file size based on the volume's file system.

Caution: Do not place your core dump partition on a SAN disk. If the SAN cable is removed, ESX Server becomes unstable.

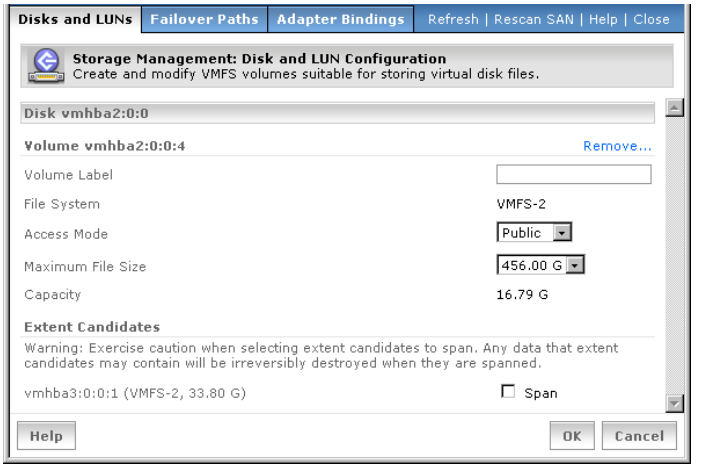
To create a new partition, complete the following steps.

1. In the Disks and LUNs window, click **Create Volume**. You are asked how you prefer to configure the disk.



2. Click **Typical**.

If it does not exist, you are asked if you want to create a core dump partition.



The core dump partition stores information generated if the VMkernel crashes. The core dump information is important in debugging any problems with the VMkernel.

The rest of the disk or array is used as a VMFS partition, where you store virtual machine disk files. The VMFS partition provides high-performance access to the virtual machine's files — essentially the same performance you would get if the virtual machine were installed on a raw SCSI partition.

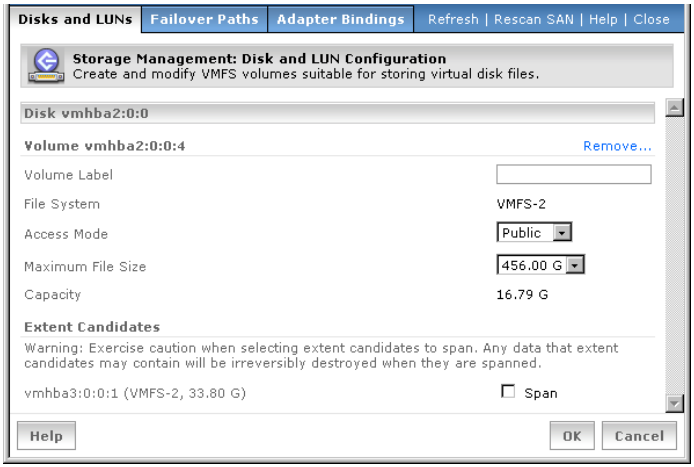
Note: Keep in mind that only four primary partitions can exist on a drive. If you have an extended partition (to contain logical partitions), that counts as one of your four primary partitions.

3. Click **Yes** to create the core dump partition. ESX Server also creates the VMFS partition.

After you create the partition, you can add a volume label, determine access mode and the maximum file size and span the disk with any public extents. For more information about access modes, see VMFS Accessibility on page 257.

Editing a Disk Partition

Select a partition to edit and click **Edit**.



ESX Server 2.1 includes a new file system, VMFS version 2 (VMFS-2). If this partition is formatted for VMFS-1, you can convert it to VMFS-2. See File System Management on SCSI Disks and RAID on page 255 for detailed information on this file system.

The changes you can make to the partition may include (certain partitions do not allow you to change all of the following):

- Setting the volume's type.
- Changing the name of the volume label.
- Setting the volume's access mode.
- Setting the volume's maximum file size.

Setting the Volume's Access Mode

There are two modes for accessing VMFS volumes: public or shared.

- **Public** mode is the default mode for ESX Server. VMware recommends you use this mode.

  With a public VMFS version 1 (VMFS-1) volume, multiple ESX Server computers have the ability to access the VMware ESX Server file system, as long as the VMFS volume is on a shared storage system (for example, a VMFS on a storage area network). However, only one ESX Server can access the VMFS volume at a time.

With a public VMFS version 2 (VMFS-2) volume, multiple ESX Server computers can access the VMware ESX Server file system concurrently. VMware ESX Server file systems with a public mode have automatic locking to ensure file system consistency.

- **Shared** mode is used for a VMFS volume that is used for failover-based clustering among virtual machines on the same or different ESX Servers.

  Note: If you plan to change the accessibility mode for a VMFS volume, you must deactivate the swap file if it exists. To deactivate the swap file, see Configuring a Swap File on page 241.

Changing the Maximum Size of a File Allowed by VMFS
If you plan to create virtual machines with virtual disks larger than the default maximum size of 144GB, change the value in the **Max File Size** field.

Spanning a VMFS volume.
You can only span VMFS-2 volumes. Spanning a volume allows the volume to comprise multiple VMFS disk partitions. Each disk or partition to which this volume is spanned is called an extent. In effect, this creates a single volume that is larger than would be possible from one partition. Also, in the spanned volume or extent, you cannot change the maximum size of files.

Once you span a volume, you cannot remove the volume if it is spanned or if it spans other volumes. To span to another volume, check the box next to that volume label.

Caution: Any data on the extent is lost when the VMFS volume spans to it, so it is a good idea to span to newly created partitions.

Converting a Partition to VMFS-2
To convert the partition to VMFS-2, click the Convert to VMFS-2 link. In order to convert the file system, you must deactivate the swap file if it exists. To deactivate the swap file, see Configuring a Swap File on page 241.

Caution: Metadata on VMFS-2 volumes utilize more space than metadata on VMFS-1 volumes. To successfully convert a file partition, you may need to move files to allow for more disk space.

Removing a Disk Partition
To remove the partition, click **Remove**. You are asked to confirm that you want to remove the partition. To delete certain partitions, you must click **Edit**, then **Remove**.

If the volume is spanned to other volumes, you cannot remove it.

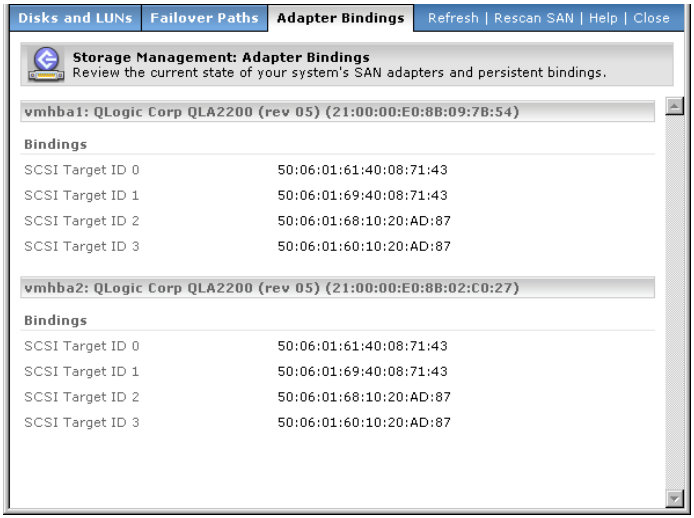
For more information, see File System Management on SCSI Disks and RAID on page 255.

- Convert the partition to VMFS-2. Click the **Convert to VMFS-2** link. In order to convert the file system, you must deactivate the swap partition if it exists. To deactivate the partition, see Configuring a Swap File on page 241.
- Removing the partition.

  Click **Remove**. You are asked to confirm that you want to remove the partition. You cannot remove a volume that is spanned.

Adapter Bindings

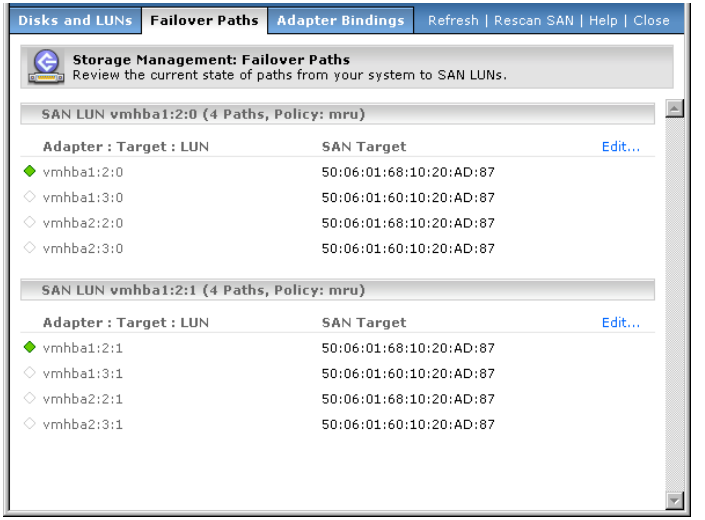
This Adapter Bindings view displays the World Wide Port Names bound to each Fibre Channel host bus adapter (HBA) in the system. You can also view the persistent binding status for each HBA. With persistent bindings, ESX Server assigns specific target IDs to specific SCSI devices. This target ID association is retained from reboot to reboot unless changed by you.


Disks and LUNs
Failover Paths
Adapter Bindings
Refresh | Rescan SAN | Help | Close
Storage Management: Adapter Bindings
Review the current state of your system's SAN adapters and persistent bindings.
vmhba1: QLogic Corp QLA2200 (rev 05) (21:00:00:E0:8B:09:7B:54)
Bindings
SCSI Target ID 0 50:06:01:61:40:08:71:43
SCSI Target ID 1 50:06:01:69:40:08:71:43
SCSI Target ID 2 50:06:01:68:10:20:AD:87
SCSI Target ID 3 50:06:01:60:10:20:AD:87
vmhba2: QLogic Corp QLA2200 (rev 05) (21:00:00:E0:8B:02:C0:27)
Bindings
SCSI Target ID 0 50:06:01:61:40:08:71:43
SCSI Target ID 1 50:06:01:69:40:08:71:43
SCSI Target ID 2 50:06:01:68:10:20:AD:87
SCSI Target ID 3 50:06:01:60:10:20:AD:87

Persistent bindings are particularly useful if you are using raw disks with ESX Server. A raw disk is directly mapped to a physical disk drive on your storage area network (SAN). ESX Server directly accesses the data on this disk as a raw device (and not as a file on a VMFS volume).

Viewing Failover Paths Connections

The Failover Paths page allows you to review the current state of paths between your system and SAN LUNs. Multipathing support allows your system to maintain a constant connection between the server machine and the storage device in case of the failure of a host bus adapter (HBA), switch, storage controller, or a Fibre Channel cable.



For each SAN Logical Unit Number (LUN), this page displays the available paths and the preferred path. By default, ESX Server selects the last path used to access a LUN.

The failover paths show the adapter, target, LUN and the SAN target for the LUN. Each SAN target is identified by its World Wide Port Name.

The status of each path is indicated by a symbol that corresponds to its current status.

◆ — This indicates that the path is active and data is being transferred successfully.

▲ — This indicates that the path is set to disabled and is available for activation.

● — This indicates that the path should be active, but the software cannot connect to the LUN through this path.

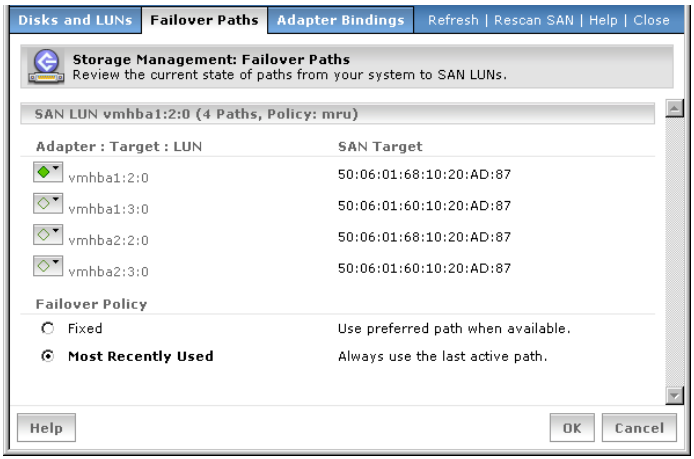
If you have configured a LUN to use a preferred path, that path will be identified with the label **Preferred** after the SAN Target listing.

Configuring Failover Policies

The failover paths edit feature allows you to configure the policy for transferring LUN access from one path to another.

To edit the failover policy for a LUN:

1. From the Failover Paths page, click **Edit**. The configuration page appears and displays information about the current state of the paths and failover policy options.



2. Choose one of the following failover policies:

- **Fixed** — always use the preferred path when available
- **Most Recently Used** — always use the last active path

3. If you select **Fixed**, next choose the preferred path by selecting **Preferred** in the **Adapter** icon pulldown menu for that path.
4. Click **OK** to save your settings and return to the Failover Paths page. The name of the failover policy appears next to each SAN LUN in the failover paths list.

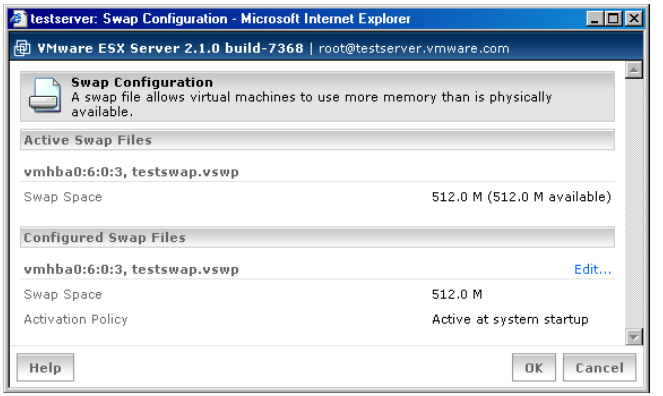
For more information on failover policies, see Setting Your Multipathing Policy for a LUN on page 326.

Configuring Failover Paths

You can also enable or disable individual failover paths by changing their status in the **Adapter** icon pulldown menu.

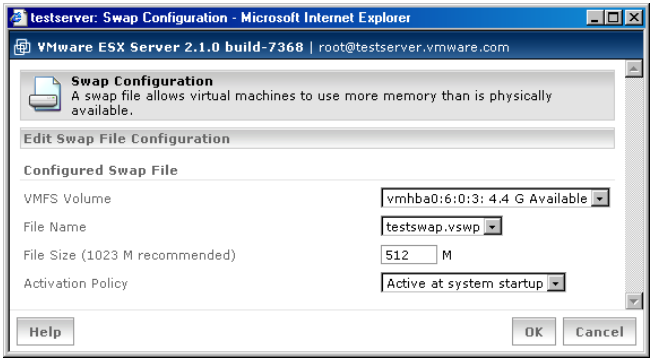
Configuring a Swap File

Use the **Swap Configuration** option to create and configure a swap file, which enables your virtual machines to use more memory than is physically available on the server. For background, see Memory Resource Management on page 363.



You can manage a single swap file with the management interface. ESX Server can manage up to 8 swap files, but you must use `vmkfstools` to do so. For information on `vmkfstools`, see Using vmkfstools on page 259.

To change your swap file settings, click **Edit**.



You can change the following settings:

- The volume on which to locate the swap file.

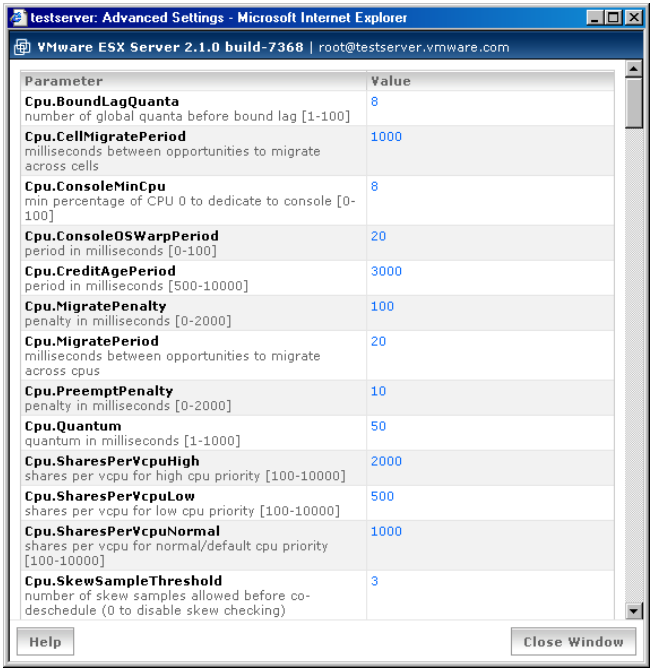
  Caution: Do not place your swap file on a SAN disk. If the SAN cable is removed, ESX Server becomes unstable.

- The name of the swap file, which defaults to `SwapFile.vswp`. To change the name of the swap file, select **Other** from the **File Name** list, then type the name of the swap file. The file must have a `.vswp` extension.
- The capacity of the swap file in MB. A recommended value is provided.
- The activation policy. The swap file can be active when the system boots, or it can be activated manually. To deactivate the swap partition, set the activation policy to **Activated manually**, then restart the server. The swap file is not deactivated until you reboot.

Note: Since you are making changes to the amount of swap space after the initial configuration, you must restart the server before the changes take effect. If the swap file is set to be activated manually, after you reboot, the swap file is not activated. To activate it manually, you must use `vmkfstools -w`.

Changing Advanced Settings

Use the **Advanced Settings** option to view and modify the configuration parameters of the VMkernel.



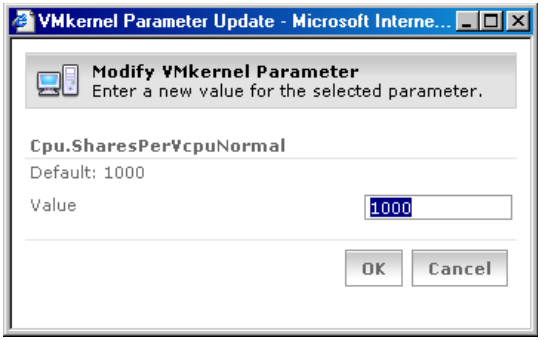
When you configure the VMware ESX Server computer (see the *VMware ESX Server Installation Guide*), various system parameters are assigned predetermined values. These parameters control settings for memory, the processor and networking, for example, and affect the running of virtual machines. You can view these settings from the management interface.

If you are logged in as the root user, you can change the values for these parameters. Changing these values can help fine tune the running of virtual machines.

Caution: You should not make any changes to these settings unless you are working with VMware's support team or otherwise have thorough information about what values you should provide for them.

Note: Some configuration settings shown on this page are described in the ESX Server manual and may be changed as described in the manual. In most cases, however, you should not modify these settings unless a VMware technical support engineer suggests that you do so.

To change the setting for a VMkernel configuration parameter, click the link for the value. The Update VMkernel Parameter Update window opens on top of the VMware Management Interface window.



In the **New Value** entry field, type the value for the parameter and click **OK**. The window closes and the updated parameter appears on the Advanced Settings page.

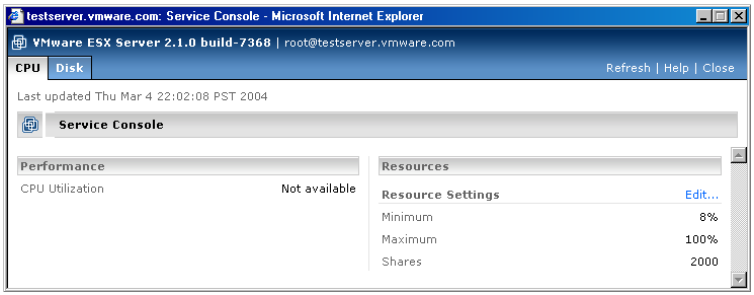
Configuring the Service Console

You can configure the server processor and disk resources for the service console. These resources are divided among the service console and all virtual disks on any VMFS partitions located on the same disk on the ESX Server system.

You must be logged into the management interface as root. Click the **Options** tab, then click **Service Console Settings**.

Configuring the Service Console's Processor Usage

To review and configure the service console's processor usage, click the **CPU** tab. The CPU page appears.



The CPU page shows how much of the server processor or processors the service console is utilizing and how CPU resources are allocated to the service console.

The values under Resources indicate a range of percentages of a processor to which the service console is entitled, where the Minimum value represents the minimum amount of processor capacity that is always available to the service console, while the Maximum value represents the highest amount of processor capacity the service console can ever consume, even if the processor is idle.

The Shares value represents a relative metric for allocating processor capacity, where this value is compared to the sum of all shares of all virtual machines on the server and the service console.

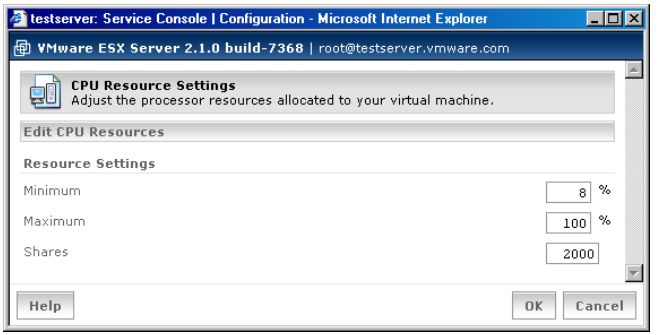
For example, a virtual machine is stored on the same drive as the service console and has a minimum CPU percentage of 20%, and a maximum CPU percentage of 50%. Meanwhile, the service console has a minimum percentage of 30% and no specified maximum percentage. You then decide to give the virtual machine 3000 CPU shares and the service console 1000 CPU shares.

ESX Server interprets this allocation so that the virtual machine never has less than 20% of the total physical CPU resources, while the service console never has less than 30% of the total physical CPU resources, in any situation.

However, if other virtual machines on the same disk are idling, then ESX Server redistributes this extra CPU time proportionally, based on the virtual machine's and service console's CPU shares. Active virtual machines benefit when extra resources are available. In this example, the virtual machine gets three times as much CPU time as the service console, subject to the specified CPU percentages.

That is, the virtual machine has three times as much CPU time as the service console, as long as the virtual machine's CPU percentage is between 20% and 50%. In actuality, the virtual machine may only get twice the CPU time of the service console, because three times the CPU time exceeds 50%, or the maximum CPU percentage of the virtual machine.

These values can be modified. Click **Edit**. The Edit CPU Resources window appears.



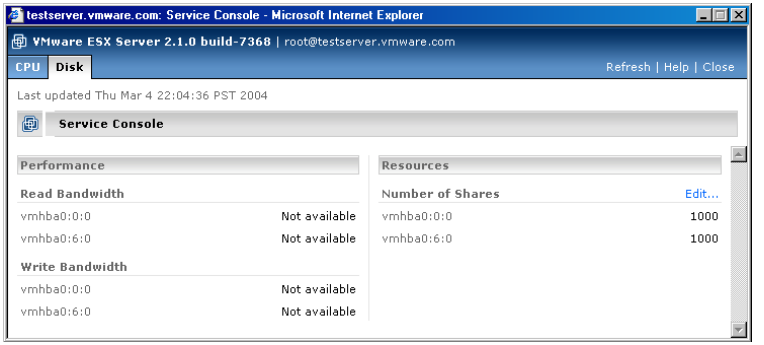
Change the settings and click **OK** to save them and close the window.

If you are running a large number of virtual machines on the same disk as the service console, consider increasing the minimum processor percentage. Otherwise, you may notice performance problems with the service console, even if the virtual machines are idle.

Click the **Disk** tab to view information about the service console processor usage.

Configuring the Service Console's Disk Usage

To review and configure the service console's disk usage, click the **Disk** tab. The Disk page appears.



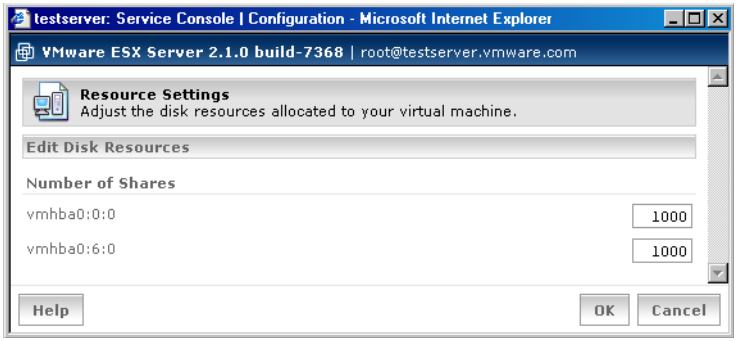
The Disk page shows hard disk performance information and resources allocated to the service console. Disk bandwidth represents the amount of data that is written to or read from the server's physical disks.

The values under Performance indicate how much bandwidth is being used when the service console is reading from or writing to the physical disk on the server.

The Shares value represents a relative metric for controlling disk bandwidth, where this value is compared to the sum of all shares of all virtual machines on the same disk as the service console and the service console itself.

For example, the service console and 2 VMFS partitions, VMFS-A and VMFS-B, are located on the same hard disk on the ESX Server system. If the service console has 2000 shares and VMFS-A and VMFS-B each have 1000 shares, then the service console has twice the disk bandwidth of both VMFS-A and VMFS-B.

The number of shares can be modified. Click **Edit**.



Change the number of shares, then click **OK** to save it and close the window.

Click the **CPU** tab to view information about service console processor usage.

Viewing System Logs and Reports

Use the **System Logs** and **Availability Report** options to view the following log files and report through the management interface:

- VMkernel warnings and serious system alerts, the data for which is gathered from `/var/log/vmkwarning` in the service console. For more information, see Viewing VMkernel Warnings on page 247.
- VMkernel messages, the data for which is gathered from `/var/log/vmkernel` in the service console. For more information, see Viewing VMkernel Messages on page 248.

- Service Console messages, the data for which is gathered from `/var/log/messages` in the service console. For more information, see Viewing Service Console Logs on page 250.
- The availability report, which contains information and statistics about server uptime and downtime. For more information, see Viewing the Availability Report on page 251.

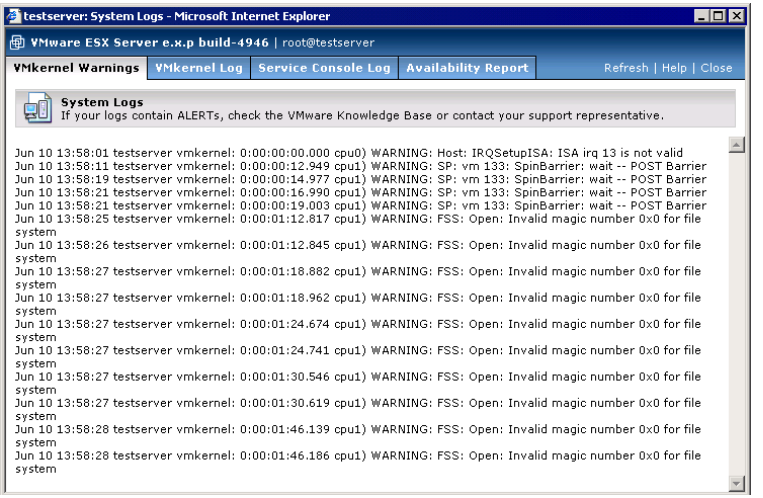
You should periodically check the VMkernel warning and alert messages for out of memory errors, hardware failures and so on.

To view these log files and the availability report, complete the following steps.

1. Make sure you are logged into the management interface as the root user.
2. Click **Options**, then click **System Logs**.
3. Click the appropriate tab for the log file you want to view.

Viewing VMkernel Warnings

To view VMkernel warnings and serious system alerts, click the **VMkernel Warnings** tab.


testserver: System Logs - Microsoft Internet Explorer
VMware ESX Server e.x.p build-4946 | root@testserver
VMkernel Warnings
VMkernel Log
Service Console Log
Availability Report
Refresh | Help | Close
System Logs
If your logs contain ALERTs, check the VMware Knowledge Base or contact your support representative.
Jun 10 13:58:01 testserver vmkernel: 0:00:00:00.000 cpu0) WARNING: Host: IRQSetupISA: ISA irq 13 is not valid
Jun 10 13:58:11 testserver vmkernel: 0:00:00:12.949 cpu1) WARNING: SP: vm 133: SpinBarrier: wait -- POST Barrier
Jun 10 13:58:19 testserver vmkernel: 0:00:00:14.977 cpu1) WARNING: SP: vm 133: SpinBarrier: wait -- POST Barrier
Jun 10 13:58:21 testserver vmkernel: 0:00:00:16.990 cpu1) WARNING: SP: vm 133: SpinBarrier: wait -- POST Barrier
Jun 10 13:58:21 testserver vmkernel: 0:00:00:19.003 cpu1) WARNING: SP: vm 133: SpinBarrier: wait -- POST Barrier
Jun 10 13:58:25 testserver vmkernel: 0:00:01:12.817 cpu1) WARNING: FSS: Open: Invalid magic number 0x0 for file system
Jun 10 13:58:26 testserver vmkernel: 0:00:01:12.845 cpu1) WARNING: FSS: Open: Invalid magic number 0x0 for file system
Jun 10 13:58:27 testserver vmkernel: 0:00:01:18.882 cpu1) WARNING: FSS: Open: Invalid magic number 0x0 for file system
Jun 10 13:58:27 testserver vmkernel: 0:00:01:18.962 cpu1) WARNING: FSS: Open: Invalid magic number 0x0 for file system
Jun 10 13:58:27 testserver vmkernel: 0:00:01:24.674 cpu1) WARNING: FSS: Open: Invalid magic number 0x0 for file system
Jun 10 13:58:27 testserver vmkernel: 0:00:01:24.741 cpu1) WARNING: FSS: Open: Invalid magic number 0x0 for file system
Jun 10 13:58:27 testserver vmkernel: 0:00:01:30.546 cpu1) WARNING: FSS: Open: Invalid magic number 0x0 for file system
Jun 10 13:58:27 testserver vmkernel: 0:00:01:30.619 cpu1) WARNING: FSS: Open: Invalid magic number 0x0 for file system
Jun 10 13:58:28 testserver vmkernel: 0:00:01:46.139 cpu1) WARNING: FSS: Open: Invalid magic number 0x0 for file system
Jun 10 13:58:28 testserver vmkernel: 0:00:01:46.186 cpu1) WARNING: FSS: Open: Invalid magic number 0x0 for file system

This information is useful if you are experiencing problems with ESX Server or your virtual machines. If your log contains any alerts, check the VMware Knowledge Base at or contact your VMware support representative. For more information, see the *VMware ESX Server Installation Guide*.

Viewing VMkernel Messages

To view the VMkernel message log, click the **VMkernel Log** tab.

This information is useful if you are experiencing problems with ESX Server or your virtual machines. If your log contains any alerts, check the VMware Knowledge Base at or contact your VMware support representative. For more information, see the *VMware ESX Server Installation Guide*.

Viewing Service Console Logs

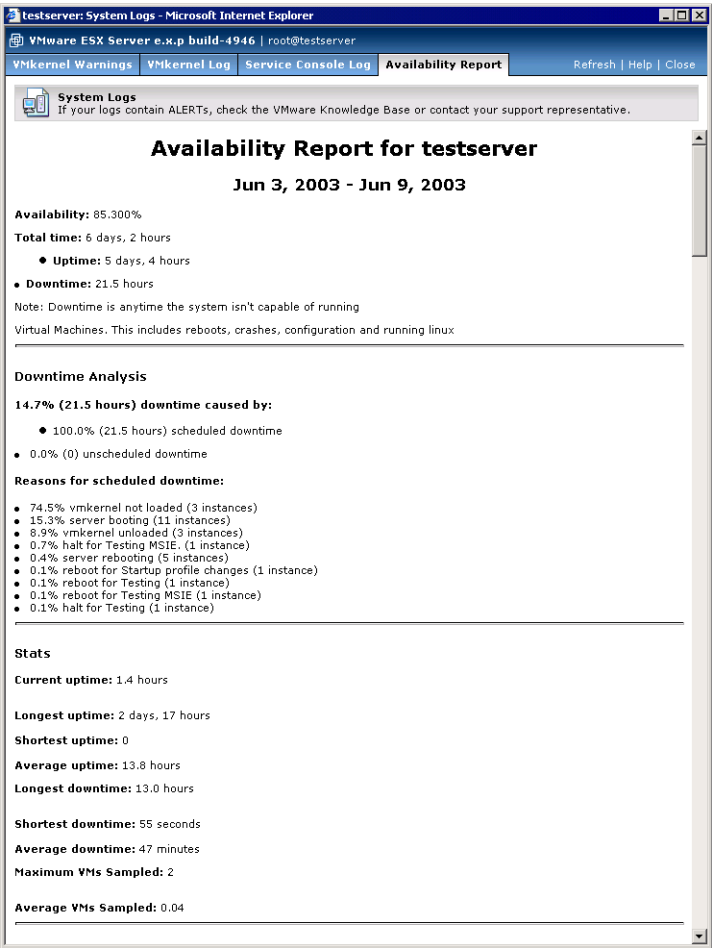
To view service console messages, click the **Service Console Log** tab.

testserver: System Logs - Microsoft Internet Explorer
VMware ESX Server e.x.p build-4946 | root@testserver
VMkernel Warnings
VMkernel Log
Service Console Log
Availability Report
Refresh | Help | Close
System Logs
If your logs contain ALERTs, check the VMware Knowledge Base or contact your support representative.
Jun 10 13:39:32 testserver syslogd 1.4.1: restart.
Jun 10 13:39:32 testserver syslog: syslogd startup succeeded
Jun 10 13:39:33 testserver kernel: klogd 1.4.1, log source = /proc/kmsg started.
Jun 10 13:39:33 testserver kernel: Inspecting /boot/System.map-2.4.9-34smp
Jun 10 13:39:33 testserver syslog: klogd startup succeeded
Jun 10 13:39:33 testserver kernel: Loaded 15872 symbols from /boot/System.map-2.4.9-34smp.
Jun 10 13:39:33 testserver kernel: Symbols match kernel version 2.4.9.
Jun 10 13:39:33 testserver kernel: Loaded 396 symbols from 11 modules.
Jun 10 13:39:33 testserver kernel: Linux version 2.4.9-34smp (bhcompile@daffy.perf.redhat.com) (gcc version 2.96
20000731 (Red Hat Linux 7.2 2.96-108.1)) #1 SMP Sat Jun 1 06:15:25 EDT 2002
Jun 10 13:39:33 testserver kernel: BIOS-provided physical RAM map:
Jun 10 13:39:33 testserver kernel: BIOS-e820: 0000000000000000 - 000000000000a0000 (usable)
Jun 10 13:39:33 testserver kernel: BIOS-e820: 00000000000f0000 - 0000000000100000 (reserved)
Jun 10 13:39:33 testserver kernel: BIOS-e820: 0000000000100000 - 000000003ff77000 (usable)
Jun 10 13:39:33 testserver kernel: BIOS-e820: 000000003ff77000 - 000000003ff79000 (ACPI NVS)
Jun 10 13:39:33 testserver kernel: BIOS-e820: 000000003ff79000 - 0000000040000000 (reserved)
Jun 10 13:39:33 testserver kernel: BIOS-e820: 00000000fec00000 - 00000000fec10000 (reserved)
Jun 10 13:39:33 testserver kernel: BIOS-e820: 00000000fee00000 - 00000000fee10000 (reserved)
Jun 10 13:39:33 testserver kernel: BIOS-e820: 00000000ffb00000 - 0000000100000000 (reserved)
Jun 10 13:39:33 testserver keytable: Loading keymap: succeeded
Jun 10 13:39:33 testserver kernel: Scanning bios EBDA for MXT signature
Jun 10 13:39:33 testserver keytable: Loading system font: succeeded
Jun 10 13:39:33 testserver kernel: 127MB HIGHMEM available.
Jun 10 13:39:33 testserver kernel: found SMP MP-table at 000fe710
Jun 10 13:39:33 testserver kernel: hm, page 000fe000 reserved twice.
Jun 10 13:39:33 testserver random: Initializing random number generator: succeeded
Jun 10 13:39:33 testserver kernel: hm, page 000ff000 reserved twice.
Jun 10 13:39:33 testserver kernel: hm, page 000f0000 reserved twice.
Jun 10 13:39:33 testserver kernel: On node 0 totalpages: 262007
Jun 10 13:39:33 testserver kernel: zone(0): 4096 pages.
Jun 10 13:39:33 testserver kernel: zone(1): 225280 pages.
Jun 10 13:39:33 testserver kernel: zone(2): 32631 pages.
Jun 10 13:39:33 testserver sshd: Generating SSH1 RSA host key:
Jun 10 13:39:33 testserver kernel: ACPI: Searched entire block, no RSDP was found.
Jun 10 13:39:33 testserver kernel: ACPI: RSDP located at physical address c00fd550
Jun 10 13:39:33 testserver kernel: RSD PTR v0 [DELL]
Jun 10 13:39:33 testserver kernel: ACPI table found: RSDT v1 [DELL WS 530 0.8]
Jun 10 13:39:34 testserver kernel: init.c:145: bad pte 000fd163.
Jun 10 13:39:34 testserver kernel: init.c:145: bad pte 000fd163.
Jun 10 13:39:34 testserver kernel: ACPI table found: FACP v1 [DELL WS 530 0.8]
Jun 10 13:39:34 testserver kernel: init.c:145: bad pte 000fd163.
Jun 10 13:39:34 testserver kernel: init.c:145: bad pte fffe6163.
Jun 10 13:39:34 testserver kernel: ACPI table found: SSDT v1 [DELL st_ex 0.4096]
Jun 10 13:39:34 testserver kernel: init.c:145: bad pte fffe6163.
Jun 10 13:39:34 testserver kernel: init.c:145: bad pte 000fd163.
Jun 10 13:39:34 testserver kernel: ACPI table found: APIC v1 [DELL WS 530 0.8]
Jun 10 13:39:34 testserver kernel: init.c:145: bad pte 000fd163.
Jun 10 13:39:34 testserver kernel: LAPIC (acpi_id[0x0001] id[0x0] enabled[1])
Jun 10 13:39:34 testserver kernel: CPU 0 (0x0000) enabledProcessor #0 Unknown CPU [15:2] APIC version 16
Jun 10 13:39:34 testserver kernel:
Jun 10 13:39:34 testserver kernel: LAPIC (acpi_id[0x0002] id[0x2] enabled[1])
Jun 10 13:39:34 testserver kernel: CPU 1 (0x0200) enabledProcessor #2 Unknown CPU [15:2] APIC version 16
Jun 10 13:39:34 testserver kernel:
Jun 10 13:39:34 testserver kernel: LAPIC (acpi_id[0x0003] id[0x1] enabled[0])
Jun 10 13:39:34 testserver kernel: CPU 2 (0x0100) disabled
Jun 10 13:39:34 testserver kernel: LAPIC (acpi_id[0x0004] id[0x3] enabled[0])
Jun 10 13:39:34 testserver kernel: CPU 3 (0x0300) disabled
Jun 10 13:39:34 testserver kernel: IOAPIC (id[0x2] address[0xfec00000] global_irq_base[0x0])
Jun 10 13:39:34 testserver kernel: INT_SRC_OVR (bus[0] irq[0x0] global_irq[0x2] polarity[0x0] trigger[0x0])
Jun 10 13:39:34 testserver kernel: INT_SRC_OVR (bus[0] irq[0x9] global_irq[0x9] polarity[0x1] trigger[0x3])
Jun 10 13:39:34 testserver kernel: 4 CPUs total
Jun 10 13:39:34 testserver kernel: Local APIC address fee00000
Jun 10 13:39:34 testserver kernel: init.c:145: bad pte 000fd163.
Jun 10 13:39:34 testserver kernel: init.c:145: bad pte 000fd163.
Jun 10 13:39:34 testserver kernel: ACPI table found: BOOT v1 [DELL WS 530 0.8]
Jun 10 13:39:34 testserver kernel: Enabling the CPU's according to the ACPI table
Jun 10 13:39:34 testserver kernel: Intel MultiProcessor Specification v1.4
Jun 10 13:39:34 testserver kernel: Virtual Wire compatibility mode.
Jun 10 13:39:34 testserver kernel: OEM ID: DELL Product ID: WS 530 APIC at: 0xFEE00000
Jun 10 13:39:34 testserver sshd: RSA1 key generation succeeded
Jun 10 13:39:34 testserver kernel: I/O APIC #4 Version 32 at 0xFEC00000.
Jun 10 13:39:34 testserver sshd: ^[[60G[
Jun 10 13:39:34 testserver kernel: Processors: 2
Jun 10 13:39:34 testserver sshd:
Jun 10 13:39:34 testserver kernel: Kernel command line: auto BOOT_IMAGE=linux ro root=802 hdc=ide-scsi
Jun 10 13:39:34 testserver kernel: ide_setup: hdc=ide-scsi
Jun 10 13:39:34 testserver kernel: Initializing CPU#0
Jun 10 13:39:34 testserver sshd: Generating SSH2 RSA host key:

This information is useful if you are experiencing problems with ESX Server or your virtual machines. If your log contains any alerts, check the VMware Knowledge Base at or contact your VMware support representative. For more information, see the *VMware ESX Server Installation Guide*.

Viewing the Availability Report

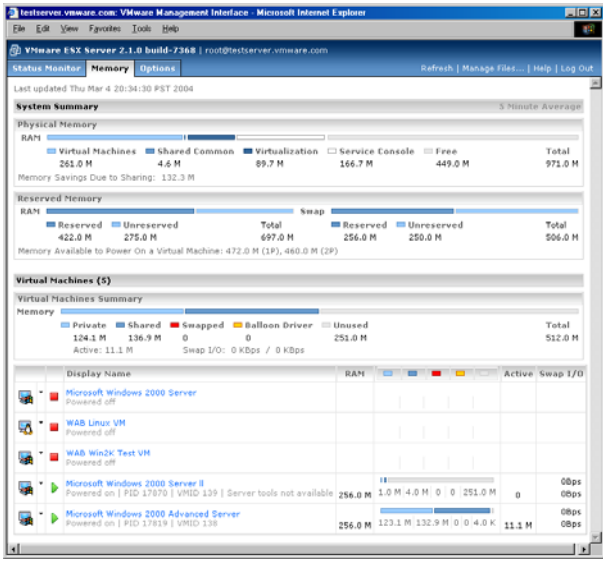
To view the server availability report, click the **Availability Report** tab.


testserver: System Logs - Microsoft Internet Explorer
VMware ESX Server e.x.p build-4946 | root@testserver
VMkernel Warnings
VMkernel Log
Service Console Log
Availability Report
Refresh | Help | Close
System Logs
If your logs contain ALERTs, check the VMware Knowledge Base or contact your support representative.
Availability Report for testserver
Jun 3, 2003 - Jun 9, 2003
Availability: 85.300%
Total time: 6 days, 2 hours
Uptime: 5 days, 4 hours
Downtime: 21.5 hours
Note: Downtime is anytime the system isn't capable of running
Virtual Machines. This includes reboots, crashes, configuration and running linux
Downtime Analysis
14.7% (21.5 hours) downtime caused by:
100.0% (21.5 hours) scheduled downtime
0.0% (0) unscheduled downtime
Reasons for scheduled downtime:
74.5% vmkernel not loaded (3 instances)
15.3% server booting (11 instances)
8.9% vmkernel unloaded (3 instances)
0.7% halt for Testing MSIE. (1 instance)
0.4% server rebooting (5 instances)
0.1% reboot for Startup profile changes (1 instance)
0.1% reboot for Testing (1 instance)
0.1% reboot for Testing MSIE (1 instance)
0.1% halt for Testing (1 instance)
Stats
Current uptime: 1.4 hours
Longest uptime: 2 days, 17 hours
Shortest uptime: 0
Average uptime: 13.8 hours
Longest downtime: 13.0 hours
Shortest downtime: 55 seconds
Average downtime: 47 minutes
Maximum VMs Sampled: 2
Average VMs Sampled: 0.04

The availability report contains useful information about server uptime and downtime. This includes detailed statistics regarding uptime history and an analysis of downtime.

Seeing How Memory Is Utilized

The Memory Utilization page shows how much memory is being used by the ESX Server and how memory resources are allocated to virtual machines. For more information about memory utilization, refer to Memory Resource Management on page 403.



System Summary: Physical Memory

This chart shows the current allocation of physical memory on the server:

- **Virtual Machines** — memory currently allocated to virtual machines
- **Shared Common** — memory required for the single copy of memory shared between virtual machines
- **Virtualization** — total virtualization overhead for all virtual machines and the vmkernel
- **Service Console** — memory allocated to the Service Console
- **Free** — memory currently available to be used by the system or virtual machines
- **Total** — total physical memory on the server

Memory

- Memory Savings Due to Sharing — amount of memory saved by sharing memory between virtual machines

  Many VMware ESX Server workloads present opportunities for sharing memory across virtual machines. For example, several VMs may be running instances of the same guest operating system, have the same applications or components loaded, or contain common data. In such cases, VMware ESX Server uses a proprietary transparent page sharing technique to securely eliminate redundant copies of memory pages. With memory sharing, a workload running as virtual machines often consumes less memory than it would when running on physical machines. As a result, higher levels of overcommitment can be supported efficiently.

System Summary: Reserved Memory

This chart shows the current allocation of reserved memory and swap space on the server:

RAM

- Reserved — memory committed for guaranteed allocations to existing virtual machines
- Unreserved — uncommitted memory available for guaranteed allocations to power on new virtual machines
- Total — total reserved and unreserved RAM memory

Swap

- Reserved — system swap file space committed for existing virtual machines
- Unreserved — total unreserved swap file space currently available to be used by virtual machines
- Total — total reserved and unreserved space in system swap files

Memory

- Memory Available to Power On a Virtual Machine — maximum memory size that can be specified when powering on the next single- or dual-processor virtual machine

Virtual Machines: Virtual Machine Summary

For each running virtual machine, this chart shows a breakdown of the virtual machine's memory allocation:

Memory

- Private — total memory allocated to virtual machines that is not shared
- Shared — total memory allocated to virtual machines and securely shared with other virtual machines
- Swapped — total memory forcibly reclaimed from virtual machines and stored in system swap files
- Balloon Driver — memory reclaimed from virtual machines by cooperation with the VMware Tools (vmmemctl driver) and guest operating systems

  This is the preferred method for reclaiming memory from virtual machines, since it reclaims the memory that is considered least valuable by the guest operating system. The system "inflates" the balloon driver to increase memory pressure within the virtual machine, causing the guest operating system to invoke its own native memory management algorithms. When memory is tight, the guest operating system decides which particular pages of memory to reclaim, and if necessary, swaps them to its own virtual disk. This proprietary technique provides predictable performance that closely matches the behavior of a native system under similar memory constraints.
- Unused — memory that has never been accessed by the virtual machines, and consequently has not yet been allocated
- Total — total memory allocated to virtual machines

Virtual Machines: Virtual Machine Name

For each running virtual machine, this chart includes a breakdown of the virtual machine's memory allocation:

- RAM — maximum amount of memory configured for use by the guest operating system running in the virtual machine. This value is often larger than the actual amount of memory currently allocated to the virtual machine, which may vary depending on the current level of memory overcommitment
- Private — memory allocated to the virtual machine that is not shared
- Shared — memory allocated to the virtual machine that is shared
- Swapped — memory forcibly reclaimed from the virtual machine and stored in the system swap files
- Balloon Driver — memory reclaimed from virtual machines by cooperation with the VMware Tools (vmmemctl driver) and the guest operating system
- Unused — memory that has never been accessed by the virtual machine, and consequently has not yet been allocated

- **Active** — memory that has been accessed recently by the virtual machine
- **Swap I/O**— rate at which the virtual machine is reading from and writing to system swap files, in bytes per second

To adjust the allocation of server memory to a virtual machine, click the virtual machine name. This takes you to the Status Monitor, where you view details about the virtual machine. Click the virtual machine's Memory tab to set the number of memory shares granted to the virtual machine.

Configuring Startup and Shutdown Options for Virtual Machines

Using the system-wide Virtual Machine Startup and Shutdown option, you can:

- Configure your server to determine if virtual machines start up or shut down when the system starts or shuts down.
- Set a delay for starting or stopping one virtual machine before starting or stopping the next. This delay helps to prevent overburdening the system due to the processor and memory capacities required to simultaneously start or stop multiple guest operating systems.
- Determine the global order in which virtual machines start and stop.

Once these settings are enabled for the system, you can customize the settings for each virtual machine. To enable these settings for a virtual machine, see Setting Startup and Shutdown Options for a Virtual Machine on page 139.

System Configuration Settings

The system-wide virtual machine startup and shutdown options include:

- **Start Up and Shutdown Virtual Machines** — whether or not virtual machines should be started and stopped with the system. If enabled, default startup and shutdown policies are applied to all virtual machines on your system (where no virtual machines are powered on when the host system starts and all virtual machines are shut down when the host system shuts down); you can customize each virtual machine's startup and shutdown policies.

  If disabled, you cannot set startup and shutdown policies for any virtual machines on your system.
- **Continue Starting Virtual Machines After** — sets the type of delay between starting up virtual machines. You can set this to:
  - **Don't Wait** — start the next virtual machine immediately.
  - **<n> Minutes** — wait **<n>** number of minutes to start the next virtual machine.
  - **Other** — specify a longer interval to wait before starting the next virtual machine.
  - **when VMWare Tools starts** — wait until VMWare Tools is operating in the current virtual machine before starting up the next virtual machine.

Note: The **when VMWare Tools starts** option applies an additional condition for starting up the next virtual machine. It does not override the delay period set in the pulldown menu.

- **Attempt to Continue Stopping Virtual Machines After** — sets the delay limit between initiating shutdowns of virtual machines. The server will stop the next virtual machine as soon as the current virtual machine shuts down. If the current virtual machine does not shut down within the delay limit, the server attempts to stop the next virtual machine.

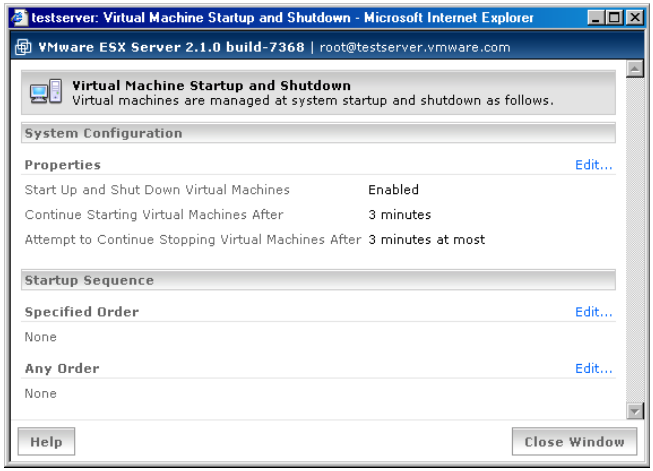
  You can set this to:

  - **Don't Wait** — stop the next virtual machine immediately.
  - **<n> Minutes at most**— wait <n> number of minutes for the current virtual machine to shutdown before stopping the next virtual machine.
  - **Other** — specify a longer interval to wait for the current virtual machine to shutdown before stopping the next virtual machine.

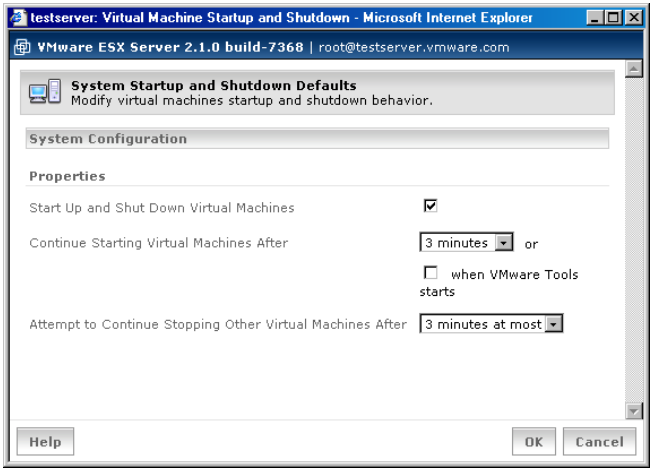
Enabling the System's Configuration Settings

To enable the system-wide configuration settings for virtual machines, complete the following steps.

1. From the **Options** tab, select **Virtual Machine Startup and Shutdown**. The System Configuration page appears and displays a list of configuration parameters.



2. Under System Configuration, click **Edit**. The System Startup and Shutdown Defaults page appears.


testserver: Virtual Machine Startup and Shutdown - Microsoft Internet Explorer
VMware ESX Server 2.1.0 build-7368 | root@testserver.vmware.com
System Startup and Shutdown Defaults
Modify virtual machines startup and shutdown behavior.
System Configuration
Properties
Start Up and Shut Down Virtual Machines
Continue Starting Virtual Machines After
3 minutes
or
when VMware Tools starts
Attempt to Continue Stopping Other Virtual Machines After
3 minutes at most
Help
OK
Cancel

3. To enable system-wide startup and shutdown policies, check the **Start Up and Shut Down Virtual Machines** check box.
4. To configure when ESX Server should start the next virtual machine after a virtual machine starts, do one or both of the following:
   - To specify a period of time before the next virtual machine starts, in the **Continue Starting Virtual Machines After** list, choose from the number of minutes listed or whether ESX Server should not wait before starting the next virtual machine. If you want to choose a number of minutes other than what is displayed in the list, select **Other** and enter the number of minutes at the prompt. It is a good idea to set a delay between starting virtual machines as this avoids placing an undue burden on the host's server's processors and memory.
   - To specify that VMware Tools should start in a virtual machine before the next virtual machine starts, check the when **VMware Tools start** check box. If VMware Tools does not start in the virtual machine before the specified time elapses, ESX Server starts the next virtual machine.
5. To configure when ESX Server should stop the next virtual machine after a virtual machine stops, in the **Attempt to Continue Stopping Other Virtual Machines After** list, choose the number of minutes or whether ESX Server should not wait before starting the next virtual machine. If you want to choose a

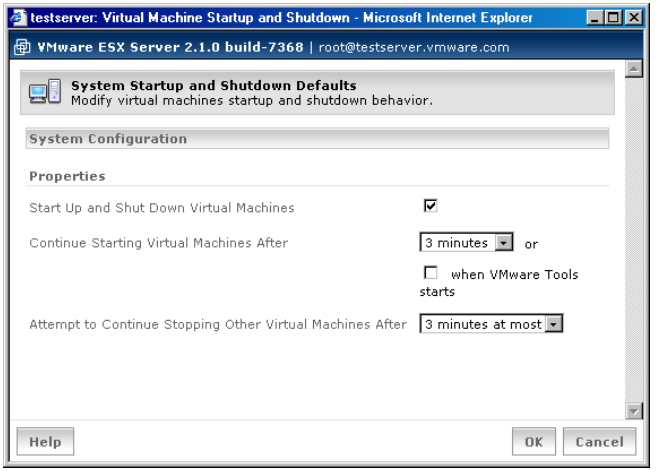
number of minutes other than what is displayed in the list, select **Other** and enter the number of minutes at the prompt.

6. Click **OK** to save your settings.
7. Click **Close Window** to return to the management interface's Options page.

Disabling the System's Configuration Settings

To disable the system-wide configuration settings, complete the following steps.

1. Under System Configuration, click **Edit**. The System Startup and Shutdown Defaults page appears.


testserver: Virtual Machine Startup and Shutdown - Microsoft Internet Explorer
VMware ESX Server 2.1.0 build-7368 | root@testserver.vmware.com
System Startup and Shutdown Defaults
Modify virtual machines startup and shutdown behavior.
System Configuration
Properties
Start Up and Shut Down Virtual Machines
Continue Starting Virtual Machines After
3 minutes
or
when VMware Tools starts
Attempt to Continue Stopping Other Virtual Machines After
3 minutes at most
Help
OK
Cancel

2. Clear the **Start Up and Shut Down Virtual Machines** check box, then click **OK**.
3. Click **Close Window** to return to the management interface's Options page.

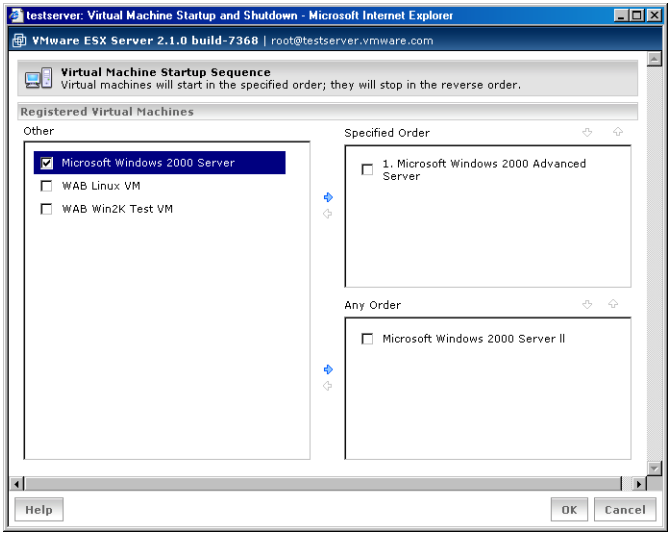
Specifying the Order in which Virtual Machines Start

Once you set whether or not virtual machines should start and stop with the system, you can set the order in which the virtual machines start and stop, allowing you to specify the position of a virtual machine in the system-wide startup and shutdown sequence. If set, virtual machines are listed under one of the following categories:

- **Specified Order** — lists the virtual machines in the order in which they are configured to start and stop.
- **Any Order** — lists the virtual machines specified to start and stop in any order.

Editing the Startup Sequence for Virtual Machines

To edit the startup sequence for virtual machines, click **Edit** under Startup Sequence. The Virtual Machine Startup Sequence configuration page appears and displays the virtual machines on your system.


testserver: Virtual Machine Startup and Shutdown - Microsoft Internet Explorer
VMware ESX Server 2.1.0 build-7368 | root@testserver.vmware.com
Virtual Machine Startup Sequence
Virtual machines will start in the specified order; they will stop in the reverse order.
Registered Virtual Machines
Other
Microsoft Windows 2000 Server
WAB Linux VM
WAB Win2K Test VM
Specified Order
1. Microsoft Windows 2000 Advanced Server
Any Order
Microsoft Windows 2000 Server II
Help
OK
Cancel

To specify the startup order for virtual machines, select the check box next to one or more machines. Once selected, navigation arrows highlight, allowing you to move machines between the three lists. Virtual machines can be set to one of the following options:

- **Other** — this list contains virtual machines that are not configured to start and stop with the system.
- **Specified Order** — lists the virtual machines in the order in which they are configured to start; the order in which the virtual machines stop is the reverse of the order in which they start, so the last virtual machine to start on system startup is the first to stop when the system shuts down. To specify the startup order, select machines and use the arrows to move them up or down within the list.
- **Any Order** — lists the virtual machines that are configured to start and stop in any order. Move virtual machines to this category if you want them to start and stop with the system, but you do not want to set the order for those virtual machines. The virtual machines in this category do not start or stop until all the virtual machines listed in the Specified Order list have started or stopped.

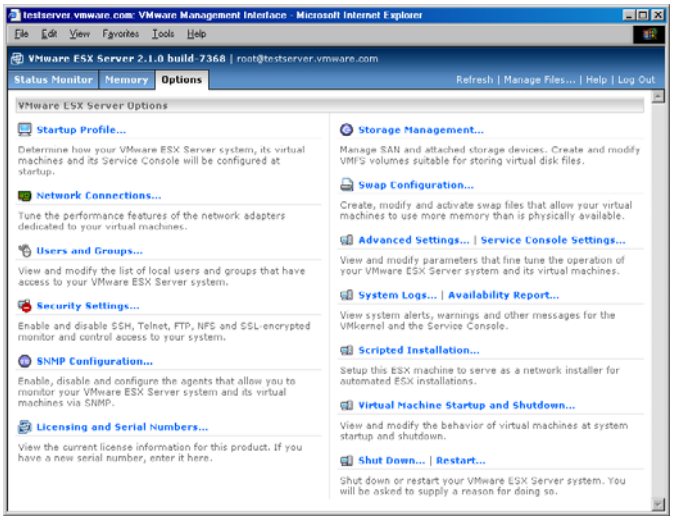
Rebooting or Shutting Down the Server

To reboot or shut down the computer where ESX Server is running:

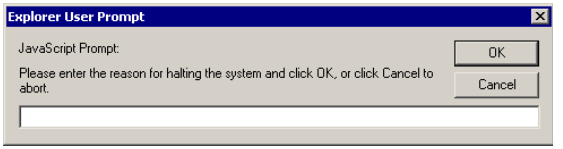
1. Log in to the management interface as root.

   The URL to connect to the server is `http://<hostname>`.

2. On the Status Monitor page, be sure all virtual machines are shut down or suspended. Then click the **Options** tab.


testserver.vmware.com: VMware Management Interface - Microsoft Internet Explorer
File Edit View Favorites Tools Help
VMware ESX Server 2.1.0 build-7368 | root@testserver.vmware.com
Status Monitor
Memory
Options
Refresh | Manage Files... | Help | Log Out
VMware ESX Server Options
Startup Profile...
Determine how your VMware ESX Server system, its virtual machines and its Service Console will be configured at startup.
Network Connections...
Tune the performance features of the network adapters dedicated to your virtual machines.
Users and Groups...
View and modify the list of local users and groups that have access to your VMware ESX Server system.
Security Settings...
Enable and disable SSH, Telnet, FTP, NFS and SSL-encrypted monitor and control access to your system.
SNMP Configuration...
Enable, disable and configure the agents that allow you to monitor your VMware ESX Server system and its virtual machines via SNMP.
Licensing and Serial Numbers...
View the current license information for this product. If you have a new serial number, enter it here.
Storage Management...
Manage SAN and attached storage devices. Create and modify VMFS volumes suitable for storing virtual disk files.
Swap Configuration...
Create, modify and activate swap files that allow your virtual machines to use more memory than is physically available.
Advanced Settings... | Service Console Settings...
View and modify parameters that fine tune the operation of your VMware ESX Server system and its virtual machines.
System Logs... | Availability Report...
View system alerts, warnings and other messages for the VMkernel and the Service Console.
Scripted Installation...
Setup this ESX machine to serve as a network installer for automated ESX installations.
Virtual Machine Startup and Shutdown...
View and modify the behavior of virtual machines at system startup and shutdown.
Shut Down... | Restart...
Shut down or restart your VMware ESX Server system. You will be asked to supply a reason for doing so.

3. Click **Restart** or **Shut Down** to reboot or shut down the server, respectively. A prompt appears.


Explorer User Prompt
JavaScript Prompt:
Please enter the reason for halting the system and click OK, or click Cancel to abort.
OK
Cancel

4. Enter the reason for the reboot or shutdown, then click **OK**. This information is logged for reliability monitoring.

The system reboots or shuts down, and you are logged out of the management interface.

CHAPTER 7

Using SNMP with ESX Server

Simple network management protocol (SNMP) is a communication protocol between the SNMP client (for example, a workstation) and the SNMP agent (management software that executes on a remote device including hosts, routers, X terminals, and so on). The SNMP client queries the SNMP agent, that provides information to the client regarding the device's status. The SNMP agent controls a database called the SNMP Management Information Base (MIB), a standard set of statistical and control values. SNMP allows the extension of these standard values with values specific to a particular device.

This chapter contains the following information about using SNMP with ESX Server:

- Using SNMP to Monitor the Computer Running ESX Server on page 266
- Setting Up and Installing for ESX Server SNMP on page 269
- Configuring the ESX Server Agent on page 271
- Configuring SNMP on page 274
- Using SNMP with Guest Operating Systems on page 275
- VMware ESX Server SNMP Variables on page 276

Using SNMP to Monitor the Computer Running ESX Server

ESX Server ships with an SNMP agent that allows you to monitor the health of the physical machine where ESX Server is running and of virtual machines running on it. This agent is based on Net-SNMP with enhancements to support data specific to ESX Server. Background information on Net-SNMP is available at *net-snmp.sourceforge.net*.

The ESX Server SNMP agent can be used with any management software that can load and compile a management information base (MIB) in SMIv1 format and can understand SNMPv1 trap messages.

The location of the VMware subtree in the SNMP hierarchy is `.iso.org.dod.internet.private.enterprises.vmware` (`.1.3.6.1.4.1.6876`).

You can choose to use SNMP with or without any specific ESX Server MIB items.

Information about the Physical Computer

SNMP `get` variables allow you to monitor a wide variety of items about the physical computer and how virtual machines are using its resources. Some of the key types of information available are:

- The number of CPUs on the physical computer
- CPU resources on the physical computer being used by particular virtual machines
- The amount of RAM installed on the physical computer
- Physical memory used by the service console
- Physical memory used by particular virtual machines
- Physical memory that is not being used
- Usage data for disks on the physical computer, including number of reads and writes and amount of data read and written
- Usage data on the physical computer's network adapters, including packets sent and received and kilobytes sent and received
- State of the VMkernel (loaded or not loaded)

  Note: If the variable showing whether the VMkernel is loaded says no, any values reported for any other variable should be regarded as invalid.

Information about the Virtual Machines

SNMP `get` variables allow you to monitor a number of items about particular virtual machines running on the computer. Some of the key types of information available are:

- The path to the virtual machine's configuration file
- The guest operating system running on the virtual machine
- The amount of memory the virtual machine is configured to use
- The state of the virtual machine's power switch — on or off
- The state of the guest operating system — on or off (running or not running)
- What disk adapters are seen by the virtual machine
- What network adapters are seen by the virtual machine
- What floppy disk drives are seen by the virtual machine
- The state of the floppy drive — connected or disconnected
- What CD-ROM drives are seen by the virtual machine
- The state of the CD-ROM drive — connected or disconnected

Note: SNMP information is provided for virtual machines if their configuration files are stored locally on the ESX Server computer. If the configuration files are stored on an NFS-mounted drive, information for the virtual machines does not appear in the SNMP tables.

SNMP Traps

Four SNMP traps notify you of critical events in particular virtual machines. The affected virtual machine is identified by ID number and configuration file path. The traps notify you

- When a virtual machine is powered on
- When a virtual machine is powered off
- When the virtual machine detects a loss of heartbeat in the guest operating system
- When the virtual machine detects that the guest operating system's heartbeat has started or resumed

Note: VMware Tools must be installed in the guest operating system to support the traps that detect loss and resumption of the guest's heartbeat.

Note: Traps are not generated immediately when virtual machines are registered using the VMware Management Interface. To enable trap generation, you must restart

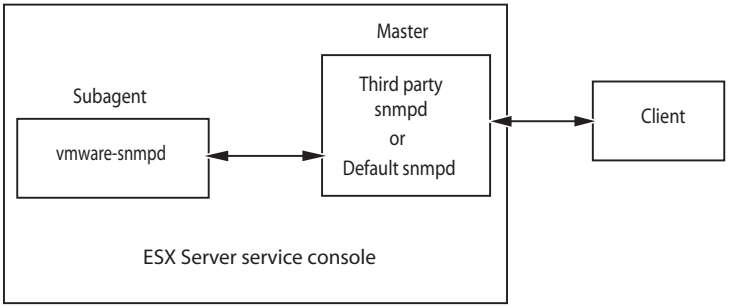
`vmware-serverd`. You may restart `vmware-serverd` by rebooting the server or by logging in to the service console as root and issuing the command

```
killall -HUP vmware-serverd
```

Setting Up and Installing for ESX Server SNMP

Setting Up VMware ESX Server SNMP

ESX Server 2.1 includes two daemons, a master (`snmpd`) and a subagent (`vmware-snmpd`), as illustrated in the following diagram. The master `snmpd` daemon is either the default `snmpd` daemon shipped with ESX Server or a third party SNMP application daemon. The subagent `vmware-snmpd` exports ESX Server MIB information to the master, that communicates directly with the SNMP client application.



Installing the ESX Server SNMP Agents

The default master `snmpd` daemon and the VMware-specific `vmware-snmpd` daemon are automatically installed when you install ESX Server.

If you want to see ESX Server MIB items, then you must configure the ESX Server SNMP subagent (`vmware-snmpd`). If you aren't interested in ESX Server-specific SNMP items, then you do not configure `vmware-snmpd`.

Configure the ESX Server SNMP subagent after you have installed and configured ESX Server through the VMware Management Interface. You can configure the ESX Server SNMP subagent by using a script or through the VMware Management Interface.

Depending on your preference, complete *one* of the following:

- Configuring the ESX Server Agent through the VMware Management Interface on page 271
- Configuring the ESX Server Agent from the Service Console on page 272

Then, configure your SNMP trap destinations. See Configuring SNMP Trap Destinations on page 274.

Configuring the ESX Server Agent

Configuring the ESX Server Agent through the VMware Management Interface

To configure the ESX Server SNMP subagent, complete the following steps.

1. Log in to the VMware Management Interface as root.

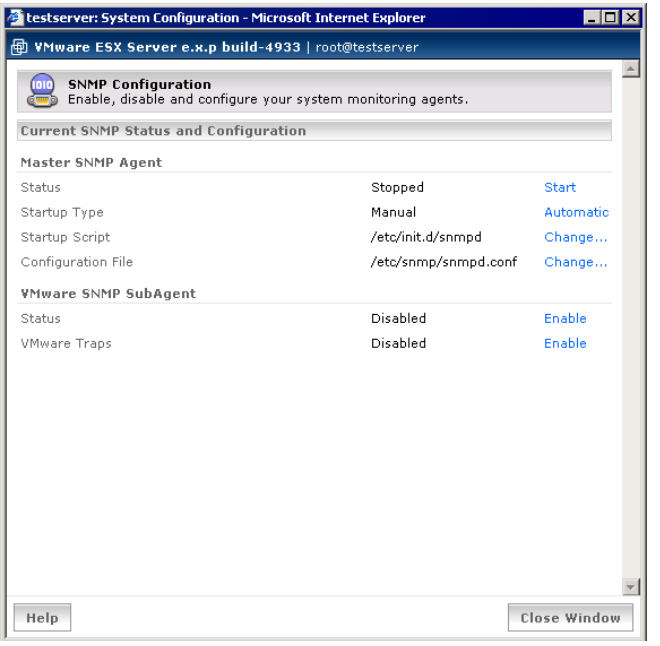
   The Status Monitor page appears.

2. Click the **Options** tab.

   The Options page appears.

3. Click **SNMP Configuration**.

   The options in this page act as toggle between two choices. To change an option, click the link.


testserver: System Configuration - Microsoft Internet Explorer
VMware ESX Server e.x.p build-4933 | root@testserver
SNMP Configuration
Enable, disable and configure your system monitoring agents.
Current SNMP Status and Configuration
Master SNMP Agent
Status Stopped Start
Startup Type Manual Automatic
Startup Script /etc/init.d/snmpd Change...
Configuration File /etc/snmp/snmpd.conf Change...
VMware SNMP SubAgent
Status Disabled Enable
VMware Traps Disabled Enable
Help
Close Window

4. Make sure the paths to the `snmpd` daemon startup script and its configuration file are correct. If either of these is incorrect, then click **Change** and type the correct path.

5. Make sure that the status of the master SNMP agent is **Running**.
6. If you're interested in VMware-specific SNMP MIBs, then make sure the status and VMware traps of the VMware SNMP subagent is **Enabled**.
7. **Optional:** If you want the master SNMP agent (and the VMware SNMP subagent, if its status is **Enabled**) to start automatically upon booting, then make sure the Startup Type is **Automatic**.
8. Configure your traps. See Configuring SNMP Trap Destinations on page 274.

Configuring the ESX Server Agent from the Service Console

Use the `snmpsetup.sh` script to configure the ESX Server SNMP subagent to work with the default `snmpd` or with a third party management application, including Dell OpenManage 3.2 or HP Insight Manager.

Note: If you're not interested in VMware-specific SNMP modules, then you shouldn't run this script. This script sets up a connection, between the master `snmpd` daemon and the `vmware-snmpd` daemon, which enables access to ESX Server MIB items.

Caution: Do not use the `snmpsetup.sh` script to set up third-party SNMP daemons.

Using the VMware SNMP Daemon with the Default SNMP Daemon

1. Log into the service console as the root user and run the script as follows.
2. Type the following

   ```
   snmpsetup.sh default
   ```

   The `default` option sets up the `snmpd.conf` file for the default master SNMP daemon. This connects `snmpd` to `vmware-snmpd`, enabling you to query for ESX Server MIB items.
3. The script then starts both the master and subagent SNMP daemons.

Using the VMware SNMP Daemon with Third Party Management Applications

1. Install your third party management application. Refer to your management application documentation and the ESX Server release notes at *www.vmware.com/support/esx2/doc/releasenotes_esx2.html* .
2. Log into the service console as the root user and run the script as follows.
3. Type the following:

   ```
   snmpsetup.sh connect
   ```

   The `connect` option configures exporting ESX Server MIB items through your third party SNMP daemon. You should use this option if you want to enable the

export of ESX Server MIB items after installing the third party management application.

The script connects the third party application `snmpd` daemon with the `vmware-snmpd` subagent daemon.

4. The script then starts both daemons.

Starting the SNMP Agents Automatically

You can set the master and subagent SNMP daemons to start automatically whenever ESX Server boots by logging in as the root user in the service console and running the `chkconfig` commands:

```
chkconfig snmpd on
chkconfig vmware-snmpd on
```

The first command enables starting the master SNMP daemon (either the default SNMP daemon shipped with ESX Server or your third party management application SNMP daemon) on boot.

The second command enables starting the subagent `vmware-snmpd` daemon on boot.

Note: The master `snmpd` daemon can run by itself or together with the subagent `vmware-snmpd` daemon. However, the subagent daemon cannot run alone.

Starting the SNMP Agents Manually

If you need to start the SNMP agents manually, log in as root in the service console and run the following commands:

```
/etc/rc.d/init.d/snmpd start
/etc/rc.d/init.d/vmware-snmpd start
```

The first command starts the master SNMP daemon (either the default SNMP daemon shipped with ESX Server or your third party management application SNMP daemon).

The second command starts the subagent `vmware-snmpd` daemon.

By default, the agents start and run as background processes.

Note: As described previously, the master `snmpd` daemon can run by itself or together with the subagent `vmware-snmpd` daemon. However, the subagent daemon cannot run alone.

Configuring SNMP

Configuring SNMP Trap Destinations

Currently, you cannot configure trap destinations through the VMware Management Interface. To configure traps, log into the service console as the root user and modify the `/etc/snmp/snmpd.conf` file as follows:

1. Using a text editor, add the following line, replacing `mercury.solar.com` with the name of the host on your network that will receive traps. You may repeat this line to specify more than one destination.

   ```
   trapsink mercury.solar.com
   ```

2. Add the following line, replacing `public` with a community name of your choice. There can only be one instance of this line.

   ```
   trapcommunity public
   ```

3. Save your changes.

Configuring SNMP Management Client Software

To use your SNMP management software with the ESX Server agent, take the normal steps needed to accomplish the following:

- In your management software, specify the ESX Server machine as an SNMP-based managed device.
- Set up appropriate community names in the management software. These must correspond to the values set in the master SNMP agent's configuration file, for example, `rocommunity`, `trapcommunity` and `trapsink`.
- Load the ESX Server MIBs into the management software so you can view the symbolic names for the ESX Server variables. You can find the MIB files on VMware ESX Server, in the `/usr/lib/vmware/snmp/mibs` directory.

Configuring SNMP Security

The ESX Server SNMP package takes the simplest approach to SNMP security in the default configuration. It sets up a single community with read-only access. This is denoted by the `rocommunity` configuration parameter in the configuration file for the master `snmpd` daemon, `snmpd.conf` which is set up for you by running `snmpsetup.sh default`.

By design, SNMP is not a very secure protocol, and the community-based security model is a retrofit to the protocol. There are other enhancements to the SNMP

security mechanism that allow an administrator to set up a more elaborate permissions scheme. See the `snmpd.conf(5)` man page for details.

Using SNMP with Guest Operating Systems

To use SNMP to monitor guest operating systems or applications running in virtual machines, install the SNMP agents you would normally use for that purpose in the guest operating systems. No special configuration is required on ESX Server.

Keep in mind that the virtual machine uses its own virtual hardware devices. You should not install in the virtual machine agents intended to monitor hardware on the physical computer.

VMware ESX Server SNMP Variables

The VMware enterprise tree is at `.iso.dod.org.internet.private.enterprises.vmware.` `(.1.3.6.1.4.1.6876.)` The tree consists of several groups; the variables in each of the groups are shown in the tables below.

Note: All variables are read-only.

The data type field refers to the SNMP type described by the structure of management information (SMI).

vmware.vmwSystem

This group consists of three simple variables providing basic information about the system.

Name	Data type	Description
vmwProdName	Display string	Product name.
vmwProdVersion	Display string	Product version.
vmwProdOID	ObjectID	A unique identifier for this product in the VMware MIB. This ID is unique with respect to versions of the same product also.

vmware.vmwVirtMachines

This group consists of virtual machine configuration information in six tables.

***vmTable* —** a table containing information on virtual machines that have been configured on the system. Each row provides information about a particular virtual machine.

Name	Data type	Description
vmIdx (Index field)	Integer	This is a dummy number for an index.
vmDisplayName	Display string	Name by which this virtual machine is displayed.
vmConfigFile	Display string	Path to the configuration file for this virtual machine.
vmGuestOS	Display string	Operating system running on this virtual machine.
vmMemSize	Integer	Memory configured for this virtual machine in MB.
vmState	Display string	Virtual machine on or off.
vmVMID	Integer	If a virtual machine is active, an ID is assigned to it (like a pid). Not all virtual machines may be active, so this cannot be used as the index.

Name	Data type	Description
vmGuestState	Display string	Guest operating system on or off.

hbaTable — a table of disk adapters seen by this virtual machine.

Name	Data type	Description
vmIdx (Index field)	Integer	This number corresponds to the index of the virtual machine in vmTable.
hbaIdx (Index field)	Integer	There is a correspondence to the order of the SCSI device module loaded into the VMkernel.
hbaNum	Display string	Device number (format: scsi*).
hbaVirtDev	Display string	Virtual device name for this adapter.

hbaTgtTable — a table of SCSI targets seen by this virtual machine.

Name	Data type	Description
vmIdx (Index field)	Integer	This number corresponds to the index of the virtual machine in vmTable.
hbaTgtIdx (Index field)	Integer	This is a dummy target index.
hbaTgtNum	Display string	Target description (format: scsi<hba>:<tgt>).

netTable — a table of network adapters seen by this virtual machine.

Name	Data type	Description
vmIdx (Index field)	Integer	This number corresponds to the index of the virtual machine in vmTable.
netIdx (Index field)	Integer	Index for this table.
netNum	Display string	Device number. (format: ethernet*)
netName	Display string	Device name of VMkernel device that this virtual network adapter is mapped to. (format: vmnic* or vmnet*)
netConnType	Display string	Connection type (user or virtual machine monitor device).

floppyTable — a table of floppy drives seen by this virtual machine.

Name	Data type	Description
vmIdx (Index field)	Integer	This number corresponds to the index of the virtual machine in vmTable.

Name	Data type	Description
fdIdx (Index field)	Integer	Index into floppy table. Order of the floppy device on this virtual machine.
fdName	Display string	Device number/name (/dev/fd0, etc. NULL if not present).
fdConnected	Display string	Is the floppy drive connected (mounted)?

cdromTable — a table of CD-ROM drives seen by this virtual machine.

Name	Data type	Description
vmIdx (Index field)	Integer	This number corresponds to the index of the virtual machine in vmTable.
cdromIdx (Index field)	Integer	Index into CD-ROM table. Order of the CD-ROM device on this virtual machine.
cdromName	Display string	Device number/name (/dev/CDROM, etc. NULL if not present).
cdromConnected	Display string	Is the CD-ROM drive connected (mounted)?

vmware.vmwResources

This group contains statistics on the physical machine's resources categorized into several subgroups.

vmware.vmwResources.vmwCPU

This group contains CPU-related information in one simple variable and one table.

Name	Data type	Description
numCPUs	Integer	Number of physical CPUs on the system.

cpuTable — CPU usage by virtual machine.

Name	Data type	Description
vmID (Index field)	Integer	ID allocated to running virtual machine by the VMkernel.
cpuShares	Integer	Share of CPU allocated to virtual machine by VMkernel.
cpuUtil	Integer	Amount of time the virtual machine has been running on the CPU (seconds).

vmware.vmwResources.vmwMemory

This group contains RAM information in three simple variables and one table.

Name	Data type	Description
memSize	Integer	Amount of physical memory present on machine (KB).
memCOS	Integer	Amount of physical memory used by the service console (KB).
memAvail	Integer	Amount of physical memory available/free (KB).

memTable — a table of memory usage by virtual machine.

Name	Data type	Description
vmID (Index field)	Integer	ID allocated to running virtual machine by the VMkernel.
memShares	Integer	Shares of memory allocated to virtual machine by VMkernel.
memConfigured	Integer	Amount of memory the virtual machine was configured with (KB).
memUtil	Integer	Amount of memory utilized by the virtual machine (KB; instantaneous).

vmware.vmwResources.vmwHBATable

This group contains physical disk adapter and targets information in one table.

vmwHBATable — the disk adapter and target information table.

Name	Data type	Description
hbaIdx (Index field)	Integer	Index into table for HBA (corresponds to the order of the adapter on the physical computer).
hbaName	Display string	String describing the disk. (format: <devname#>:<tgt>:<lun>)
vmID	Integer	ID assigned to running virtual machine by the VMkernel.
diskShares	Integer	Share of disk bandwidth allocated to this virtual machine.
numReads	Integer	Number of reads to this disk since disk module was loaded.
kbRead	Integer	KB read from this disk since disk module was loaded.
numWrites	Integer	Number of writes to this disk since disk module was loaded.
kbWritten	Integer	KB written to this disk since disk module was loaded.

vmware.vmwResources.vmwNetTable

This group contains network statistics organized by network adapter and virtual machine, in one table.

***vmwNetTable* —** network adapter statistics.

Name	Data type	Description
netIdx (Index field)	Integer	Index into table for Net (corresponds to the order of the adapter on the physical computer).
netName	Display string	String describing the network adapter (format: vmnic* or vmnet*).
vmID	Integer	ID assigned to running virtual machine by the VMkernel.
ifAddr	Display string	MAC address of virtual machine's virtual network adapter.
netShares	Integer	Share of net bandwidth allocated to this virtual machine. (reserved for future use)
pktsTx	Integer	Number of packets transmitted on this network adapter since network module was loaded.
kbTx	Integer	KB sent from this network adapter since network module was loaded.
pktsRx	Integer	Number of packets received on this network adapter since network module was loaded.
kbRx	Integer	KB received on this network adapter since system start.

vmware.vmwProductSpecific
This group contains variables categorized into product-specific subgroups.

vmware.vmwProductSpecific.vmwESX
This group contains variables specific to VMware ESX Server.

vmware.vmwProductSpecific.vmwESX.esxVMKernel
This group contains variables specific toVMware ESX Server's VMkernel. It contains one simple variable.

Name	Data type	Description
vmkLoaded	Display string	Has the VMkernel been loaded? (yes/no)

Note: If the variable showing the state of the VMkernel says no, any values reported for quantitative variables should be regarded as invalid.

vmware.vmwTraps
This group contains the variables defined for VMware traps and related variables for use by the trap receiver (for example, `snmptrapd`).

Name	Data type	Description
vmPoweredOn	Trap	This trap is sent when a virtual machine is powered on.

Name	Data type	Description
vmPoweredOff	Trap	This trap is sent when a virtual machine is powered off.
vmHBLost	Trap	This trap is sent when a virtual machine detects a loss in guest heartbeat.
vmHBDetected	Trap	This trap is sent when a virtual machine detects or regains the guest heartbeat.
vmID	Integer	This is the vmID of the affected virtual machine in the preceding traps. If the vmID is nonexistent, (such as for a power-off trap) -1 is returned.
vmConfigFile	Display string	This is the configuration file of the affected virtual machine in the preceding traps.

vmware.vmwOID

There are no variables in this group. This group is used to allocate a unique identifier for the product denoted by the vmwSystem.vmwOID variable.

vmware.vmwExperimental

There are currently no variables in this group. This group is reserved for VMware ephemeral, experimental variables.

CHAPTER 8

Using VMkernel Device Modules

The ESX Server virtualization layer, also known as the VMkernel, runs on the native hardware. It manages all the operating systems on the machine, including both the service console and the guest operating systems running on each virtual machine.

The VMkernel supports device driver modules. Using these modules, the VMkernel can provide access to all devices on the server.

This chapter includes the following sections:

- Configuring Your Server to Use VMkernel Device Modules on page 284
- Controlling VMkernel Module Loading During Bootup on page 288

Configuring Your Server to Use VMkernel Device Modules

Loading VMkernel Device Modules

The installation process should detect the devices that are assigned to the VMkernel and automatically load appropriate modules into the VMkernel to make use of these devices.

However, there may be situations in which you wish to load VMkernel device modules explicitly. Modules supported in this release are located in `/usr/lib/vmware/vmkmod`. The command `vmkload_mod(1)` loads VMkernel modules.

VMkernel Module Loader

The program `vmkload_mod` is used to load device driver and network shaper modules into the VMkernel. `vmkload_mod` can also be used to unload a module, list the loaded modules and list the available parameters for each module.

The format for the command is

```
vmkload_mod <options> <module-binary> <module-tag>
<parameters>
```

where `<module-binary>` is the name of the module binary that is being loaded. `<module-tag>` is the name that the VMkernel associates with the loaded module. The tag can be any string of letters and numbers. If the module is a device driver, the VMkernel names the module with the `<module-tag>` plus a number starting from zero. If there are multiple device instances created by loading the module or multiple device driver modules loaded with the same tag, each device gets a unique number based on the order in which device instances are created.

The `<module-binary>` and `<module-tag>` parts of the command line are required when a module is loaded and are ignored when the `--unload`, `--list` and `--showparam` options are used. The `<parameters>` part of the command line is optional and is used only when a module is being loaded.

Options

`-l`
`--list`
List out the current modules loaded. If the `-l` option is given, other arguments on the command line are ignored.

`-u <module-binary>`
`--unload <module-binary>`
Unload the module named `<module-binary>`.

`-v`
`--verbose`
Be verbose during the module loading.

`-d <scsi-device-name>`
`--device <scsi-device-name>`
The module being loaded is for a SCSI adapter that is currently being used by the service console. After the module is loaded the SCSI adapter is controlled by the VMkernel but the service console continues to be able to access all SCSI devices. The format of `<scsi-device-name>` is `<PCI-Bus>:<PCI-slot>`.

`-e`
`--exportsym`
Export all global exported symbols from this module. This allows other modules to use exported functions and variables from the loaded module. This option should not be used for normal device driver and shaper modules since there may be symbol conflicts.

`-s`
`--showparam`
List all available module parameters that can be specified in the `<parameter>` section of the command line.

Parameters
Modules can specify parameters that can be set on the command line. A list of these parameters is shown via the `--showparam` option. In order to set one of these parameters, you must specify a name-value pair at the end of the command line. The syntax is of the form `<name>=<value>`. Any number of parameters can be specified.

Examples
`vmkload_mod ~/modules/e100.o vmnic debug=5`
loads the module `~/modules/e100.o` into the VMkernel. The tag for this module is `vmnic`. Each EEPro card that was assigned to the VMkernel is given the name `vmnic<#>`, where `<#>` starts at 0. For example, if there are two EEPro cards assigned to the VMkernel, they have VMkernel names of `vmnic0` and `vmnic1`. The module parameter `debug` is set to the value 5.

`vmkload_mod --device 0:12 ~/modules/aic7xxx.o vmhba` loads the module `~/modules/aic7xxx.o` into the VMkernel. The tag for this module is `vmhba`. The Adaptec SCSI adapter is currently being used by the service console. The SCSI adapter is located on PCI bus 0, slot 12.

`vmkload_mod --exportsym ~/modules/vmklinux linuxdrivers` loads the module `~/modules/vmklinux` into the VMkernel. All exported symbols from this module are available to other modules that are subsequently loaded. The `vmklinux` module is the module that allows Linux device drivers to run in the VMkernel so it is one of the few modules for which the `--exportsym` option makes sense.

Here are several examples of command lines that load various modules:

Preparing to Load Modules

```
vmkload_mod -e /usr/lib/vmware/vmkmod/vmklinux linux
```

This command must be given before you load other device modules. It loads common code that allows the VMkernel to make use of modules derived from Linux device drivers to manage its high-performance devices. The `-e` option is required so that the `vmklinux` module exports its symbols, making them available for use by other modules.

Loading Modules

```
vmkload_mod /usr/lib/vmware/vmkmod/e100.o vmnic
vmkload_mod /usr/lib/vmware/vmkmod/aic7xxx.o vmhba
```

The first of these commands loads a module to control the EEPro Ethernet device(s) reserved for the VMkernel. The second loads a module to control the Adaptec SCSI device(s). The last argument supplied (`vmnic` and `vmhba` in the above examples) determines the base name that VMware uses to refer to the device(s) in the VMware virtual machine configuration file.

For example, suppose your machine has two EEPro Ethernet cards and three Adaptec SCSI cards, and you assigned one Ethernet card and two SCSI cards to the VMkernel during the installation process. After you issue the two commands above, the EEPro Ethernet card assigned to the VMkernel is given the name `vmnic0` and the two SCSI cards assigned to the VMkernel are given the names `vmhba0` and `vmhba1`.

Note: You only need to load the Adaptec VMkernel module once, even though two Adaptec SCSI cards are assigned to the VMkernel.

The VMkernel can also share SCSI adapters with the service console, rather than exclusively controlling them. The installation process allows you to specify SCSI

adapters that are shared and load the device module appropriately. However, if you wish to control the sharing explicitly, assign the SCSI device to the service console during the installation process. Then load the VMkernel SCSI module using the following syntax:

```
vmkload_mod -d bus:slot \
/usr/lib/vmware/vmkmod/aic7xxx.o vmhba
```

Note: This command should be entered on a single line. Do not type the backslash.

To obtain the bus and slot (also known as device or cardnum) information, examine `/proc/pci`, output from the `scanpci` command, or both.

Note: The device must be correctly assigned to the service console. Devices assigned exclusively to the VMkernel during the installation process no longer appear in `/proc/pci`.

After you load a VMkernel device module, an entry appears in `/proc/vmware/net` or `/proc/vmware/scsi`. For example, when `e100.o` is loaded as described above, the entry `/proc/vmware/net/vmnic0` appears, indicating there is one EEPro card controlled by the VMkernel and available as `vmnic0` to the virtual machines. See Creating and Configuring Virtual Machines on page 32 for information on how to configure virtual machines to use VMkernel devices.

Other Information about VMkernel Modules

The only non-device VMkernel module available in this release of VMware ESX Server is the `nfshaper` module, which provides support for network filtering, as described in Managing Network Bandwidth on page 388. Load `nfshaper` using the following syntax.

```
vmkload_mod /usr/lib/vmware/vmkmod/nfshaper.o nfshaper
```

VMkernel modules must be reloaded each time the VMkernel is loaded (as described in Loading VMkernel Device Modules on page 284).

Controlling VMkernel Module Loading During Bootup

You can customize the loading of VMkernel device driver modules during bootup by editing one of the following files:

- `/etc/vmware/hwconfig` — Automatically supply extra parameters to a driver when it is loaded during bootup.
- `/etc/vmware/vmkmodule.conf` — Supply extra parameters to a driver, add or prevent a driver module from loading, or determine the order in which the driver modules are loaded during bootup.

Caution: Editing these files are recommended for advanced users only. If you have any questions, be sure to contact your authorized service provider before editing these files.

Customizing Parameters of VMkernel Device Driver Modules on Bootup

Caution: Do not modify the `/etc/vmware/hwconfig` file other than to add extra parameters, as described in this section. Instead, use the VMware Management Interface to manage your hardware.

You can supply extra parameters to be passed to a driver when it is loaded during bootup. You do this by editing the file `/etc/vmware/hwconfig`. This file contains information about the hardware on your system, including device driver modules.

As an example of passing a parameter to the Emulex device driver, first identify the bus, slot and function holding the first (or only) Emulex card. (You can find this information by looking at the Startup Profile page in the Options tab of the VMware Management Interface.) Then add a line with the format

```
device.vmnix.6.14.0.options = "lpfc_delay_rsp_err=0"
```

to the end of `/etc/vmware/hwconfig`. Here, the numbers `6.14.0` specify the bus, slot and function where the Emulex card is located. If you have more than one Emulex card, you should have only a line referencing the first card.

Customizing Loading of VMkernel Device Driver Modules on Bootup

You can completely customize the loading of modules at bootup time by editing the `/etc/vmware/vmkmodule.conf` file. By adding or removing entries from this file, you can add or prevent a device driver module from loading. Also, by rearranging the order of the device driver modules in this file, you can specify the order in which these modules are loaded during bootup. You can also supply extra parameters to a driver when it is loaded on bootup.

Note: If you use this file to customize the loading of device driver modules, then you must manually update this file whenever you add new hardware. Consequently, we recommend using the VMware Management Interface to manage your hardware, or if you need to add extra parameters, then editing the `hwconfig` file as described in the previous section.

The `vmkmodule.conf` file takes effect only if it contains a comment line containing the keyword `MANUAL-CONFIG`. Otherwise, the configuration is obtained automatically from the management interface.

Each non-blank line that does not begin with `#` should contain the name of a module file, the tag to be associated with the module in the VMkernel and possibly a sharing specification (the argument specified with the `-d` flag above). The module file should just be the base file name, without the `/usr/lib/vmware/...` path.

A sample `vmkmodule.conf` file is:

```
# MANUAL-CONFIG
vmklinux.o linux
nfshaper.o nfshaper
e100.o vmnic
aic7xxx.o vmhba -d 0:1
```

CHAPTER 9

Storage and File Systems

This chapter contains information about SCSI disks. These disks may be accessed by local SCSI adapters, or on a Storage Area Network (SAN) by Fibre Channel adapters. Therefore, whenever we describe SCSI adapters in this chapter, these descriptions also apply to Fibre Channel adapters, even though they are not explicitly mentioned.

This chapter provides the following information:

- File System Management on SCSI Disks and RAID on page 292
- Using vmkfstools on page 296
- Determining SCSI Target IDs on page 311
- Sharing the SCSI Bus on page 313
- Using Storage Area Networks with ESX Server on page 315
- Using Persistent Binding on page 320
- Using Multipathing in ESX Server on page 323

File System Management on SCSI Disks and RAID

VMFS (VMware ESX Server File System) is a simple, high-performance file system on physical SCSI disks and partitions, used for storing large files such as the virtual disk images for ESX Server virtual machines and, by default, the memory images of suspended virtual machines. The VMFS also stores the redo-log files for virtual machines in nonpersistent, undoable, or append disk modes. For more information on disk modes, see Creating a New Virtual Machine on page 38.

ESX Server 2.1 supports two types of file systems: VMFS version 1 (VMFS-1) or VMFS version 2 (VMFS-2). VMFS-1 is the same VMFS shipped with previous versions of ESX Server 1.x. VMFS-2 is a new VMFS released with ESX Server 2.1 and contains the following features that are not available with the older VMFS-1 file system:

- Ability to span multiple VMFS-2 partitions on the same or different SCSI disks.
- Ability for multiple ESX Servers (and the virtual machines on these servers) to access files on a VMFS-2 volume concurrently (non-clustering setup).

  VMware ESX Server 2.1 includes a new automatic per-file locking mechanism that allows these concurrent accesses without file system corruption.
- Larger file system volumes and larger files on the VMFS volumes.
- Raw disks can be mapped as VMFS files.

Note: Unlike VMFS-1, VMFS-2 is not backwardly compatible with previously released (1.x) versions of ESX Server.

A server's VMFS volumes are mounted automatically by the service console, as soon as the storage adapter drivers are loaded, and appear in the `/vmfs` directory.

The `vmkfstools` command provides additional functions that are useful when you need to create files of a particular size and when you need to import files from and export files to the service console's file system. In addition, `vmkfstools` is designed to work with large files, overcoming the 2GB limit of some standard file utilities.

Viewing and Manipulating Files in the /vmfs Directory

You can view and manipulate files under `/vmfs` in these mounted VMFS volumes with ordinary file commands such as `ls` and `cp`. Although mounted VMFS volumes may appear similar to any other file system such as ext3, VMFS is primarily intended to store large files such as disk images. Unfortunately, the service console (which is based on a Linux 2.4 kernel) does not support files greater than 2GB. `nfs` is known to run into this limitation, while `ftp`, `scp` and `cp` are not affected by it. Thus, you should use `ftp`, `scp` and `cp` for copying files to and from a VMFS volume, as long as the host file system supports these large files.

Note: If you use the `ls` command inside a `ftp` session, the file size may be different from the output of the `ls -l` command or `vmkfstools -l` command. This is because `ftp` uses 32-bit values for file sizes, and the maximum file size it can display is 4GB. However, you can safely transfer any large files between ESX Server machines with a `ftp` session. The entire file is correctly copied over.

VMFS Volumes

In ESX Server 2.1, a VMFS-2 volume can span multiple partitions, across the same or multiple (up to 32) LUNs or physical disks. A VMFS-2 volume is a logical grouping of physical extents. Each physical extent is part of a disk; for example, a physical disk partition. That is, a physical extent is a disk partition that is part of a VMFS-2 volume.

By contrast, VMFS-1 volumes are limited to a single physical extent.

You can view the VMFS volumes on your ESX Server at any time by changing directories to the /vmfs directory, then listing its contents. You can use `vmkfstools -P <VMFS_volume_label>`, to obtain more details about your VMFS volume.

```
# cd /vmfs
# ls
vmhba0:0:0:2 vmhba0:0:0:6
```

The entries in the `/vmfs` directory are updated dynamically. Any changes you make to VMFS-2 volumes through the VMware Management Interface are immediately reflected in this directory.

For more details on `vmkfstools`, see Using vmkfstools on page 296.

Labelling VMFS Volumes

If you create a VMFS volume on a SCSI disk or partition, you can give a label to that volume and use that label when specifying VMFS files on that volume. For instance, suppose you have a VMFS volume on the SCSI partition `vmhba0:3:0:1` and have created a VMFS file `nt4.dsk`. You can label that volume by using a `vmkfstools` command such as:

```
vmkfstools -S mydisk vmhba0:3:0:1
```

You can then refer to the `nt4.dsk` file as `mydisk:nt4.dsk` (instead of `vmhba0:3:0:1:nt4.dsk`) in a virtual machine configuration file and in other `vmkfstools` commands. For more information on `vmkfstools`, see vmkfstools Options on page 297.

If there is no persistent binding, then labelling VMFS volumes is especially useful if you may be adding SCSI adapters or disks to your system. The actual disk and target numbers specifying a particular VMFS may change, but the label stays the same. Also, other ESX Servers see the same label, which is useful for LUN ID between servers.

For more information, see Using Persistent Binding on page 320.

VMFS Accessibility

There are two modes for accessing VMFS volumes: public and shared.

- public — This is the default mode for ESX Server.

  With a public VMFS version 1 (VMFS-1) volume, multiple ESX Server computers have the ability to access the VMware ESX Server file system, as long as the VMFS volume is on a shared storage system (for example, a VMFS on a storage area network). However, only one ESX Server can access the VMFS volume at a time.

  With a public VMFS version 2 (VMFS-2) volumes, multiple ESX Server computers can access the VMware ESX Server file system concurrently. VMware ESX Server file systems with a public mode have automatic locking to ensure file system consistency.

- shared — Used for a VMFS volume that is used for failover-based clustering among virtual machines on the same or different ESX Servers.

  For more information on clustering with ESX Server, see Configuration for Clustering on page 329.

Note: In ESX Server 2.1, private VMFS volumes are deprecated. If you have existing VMFS version 1 (VMFS-1) or VMFS version 2 (VMFS-2) private volumes, then you can continue to use them, but we recommend you change the access mode to public. There is no performance penalty in making this change.

VMFS Accessibility on a SAN

Any VMFS volume on a disk that is on a SAN should have VMFS accessibility set to public or shared. Public, the default and recommended accessibility mode, makes the VMFS volume available to multiple physical servers, and to the virtual machines on those servers. With VMFS-2 volumes, public access is concurrent to multiple physical servers, whereas for VMFS-1 volumes, public access is limited to a single server at a time. For more information on configuring ESX Server with a SAN, see Using Storage Area Networks with ESX Server on page 315.

Changing Storage Configuration Options

To create or modify disk partitions through the VMware Management Interface, complete the following steps.

1. Log in to the VMware Management Interface as root.

   The Status Monitor page appears.

2. Click the **Options** tab.
3. Click **Storage Configuration**.
4. Make the appropriate changes, then click **OK**.

   Note: You cannot change VMFS accessibility if there are any open files on the VMFS volume. (The attempted operation returns errors). Close any open files, then edit the VMFS volume.

See Configuring Storage: Disk Partitions and File Systems on page 233 for additional information.

Using vmkfstools

The `vmkfstools` command supports the creation of a VMware ESX Server file system (VMFS) on a SCSI disk. Use `vmkfstools` to create, manipulate and manage files stored in VMFS volumes. You can store multiple virtual disk images on a single VMFS volume.

Note: You can also do most of the `vmkfstools` operations through the VMware Management Interface.

vmkfstools Command Syntax

Note: You must be logged in as the root user to run the `vmkfstools` command.

vmkfstools Syntax When Specifying a SCSI Device

The format for the `vmkfstools` command, when specifying a SCSI device, is:

```
vmkfstools <options> <device_or_VMFS_volume>[:<file>]
```

where `<device_or_VMFS_volume>` specifies a SCSI device (a SCSI disk or a partition on a SCSI disk) being manipulated or a VMFS volume, and `<options>` specifies the operation to be performed.

If `<device_or_VMFS_volume>` is a SCSI device, then it is specified in a form such as:

```
vmhba1:2:0:3
```

Here, `vmhba1` specifies the second SCSI adapter activated by the command `vmkload_mod .../XXX.o vmhba`. (See VMkernel Module Loader on page 284 for details on `vmkload_mod`.) The second number specifies the target on the adapter, the third number specifies the LUN (logical unit number) and the fourth number specifies the partition. Partition 0 (zero) implies the whole disk; otherwise, the number specifies the indicated partition.

`<device_or_VMFS_volume>` may also be a VMFS volume label, as set in the management interface or with the `vmkfstools --setfsname` command.

`<file>` is the name of a file stored in the file system on the specified device.

vmkfstools Syntax When Specifying a VMFS Volume or File

The format for the `vmkfstools` command, when specifying a VMFS volume or file, is:

```
vmkfstools <options> <path>
```

where `<path>` is an absolute path that names a directory or a file under the `/vmfs` directory.

For example, you can specify a VMFS volume by a path such as:

```
/vmfs/vmhba1:2:0:3
```

You can also specify a single VMFS file:

```
/vmfs/lun1/rh9.dsk
```

vmkfstools Options

This section includes a list of all the options used with the `vmkfstools` command.

Some of the tasks in this section include options that are suggested for advanced users only. These advanced options are not available through the VMware Management Interface.

Note: The long and short (single letter) forms of options are equivalent. For example, the following commands are identical:

```
vmkfstools --createfs vmfs2 --blocksize 2m --numfiles 32
vmhba1:3:0:1
```

```
vmkfstools -C vmfs2 -b 2m -n 32 vmhba1:3:0:1
```

If the `vmkfstools` command fails, and you don't know why, then check the log files in `/var/log/vmkernel` or use the management interface to view the latest warning.

1. Log in to the VMware Management Interface as root.

   The Status Monitor page appears.

2. Click the **Options** tab.

   The Options page appears.

3. Click **System Logs**.

Basic vmkfstools Options

Basic options are common tasks that you may perform frequently. You may also perform through the management interface.

Creates a VMFS on the specified SCSI device

```
-C --createfs [vmfs1|vmfs2]
-b --blocksize #[gGmMkK]
-n --numfiles #
```

This command creates a VMFS version1 (`vmfs1`) or version 2 (`vmfs2`) file system on the specified SCSI device.

For advanced users:

- Specify the block size by using the `-b` option. The block size must be 2^X (a power of 2) and at least 1MB. (The default file block size is 1MB.) You can specify the size in kilobytes, megabytes, or gigabytes by adding a suffix of `k` (kilobytes), `m` (megabytes), `g` (gigabytes) respectively.
- Specify the maximum number of files in the file system with the `-n` option. The default maximum number of files is 256 files.

Lists the attributes of a VMFS volume or a raw disk mapping

```
-P --querypartitions <VMFS_volume_name>
-P --querypartitions <VMFS_volume:fileName>
```

For a `VMFS_volume_name`, the listed attributes include the VMFS version number (VMFS-1 or VMFS-2), the number of physical extents (partitions) comprising the specified VMFS volume, the volume label (if any), the UUID (if any), and a listing of the SCSI device names of all the physical extents comprising the VMFS volume.

For a `VMFS_volume:fileName`, the listed attributes include the `vmhba` name of the raw disk or partition, corresponding to the mapping referenced by `fileName`, and any identification information for the raw disk.

Creates a file with the specified size on the file system of the specified SCSI device

```
-c --createfile #[gGmMkK]
```

The size is specified in bytes by default, but you can specify the size in kilobytes, megabytes, or gigabytes by adding a suffix of `k` (kilobytes), `m` (megabytes), `g` (gigabytes) respectively.

Exports the contents of the specified file on the specified SCSI device to a virtual disk on the file system of the service console

```
-e --exportfile <dstFile>
```

After the export, you may transfer the virtual disk to another server machine and import it to a SCSI device on the remote machine.

If your virtual disk has redo logs, you have the following options:

- If you use the `exportfile` option on the base virtual disk, only the base virtual disk is exported. Any uncommitted redo logs are not exported, but can be copied out separately.
- If you use the `exportfile` option on a ESX Server redo log, the exported virtual disk contains the redo log, any previously created redo logs, and the base virtual disk. That is, the newly created exported virtual disk appears as if the redo log(s) was committed to its base virtual disk.

Note: However, your original source redo log(s) and base virtual disk remain unchanged.

- If you want to export your redo logs and base virtual disk separately, then use the `exportfile` option to export the base virtual disk, and the cp command to export each redo log separately.

Use the combination of `exportfile` and `importfile` together to copy VMFS files to remote machines. The virtual disk should take less space than the full size of the VMFS file, since the virtual disk does not include zeroed sectors of the VMFS file.

Imports the contents of a VMware virtual, plain, or raw disk on the service console to the specified file on the specified SCSI device

```
-i --importfile <srcFile>
```

This command is often used to import the contents of a VMware Workstation or VMware GSX Server virtual disk onto a SCSI device. You may also run this command to import a virtual disk, that was created by exporting the contents of a disk from another SCSI device.

Note: The destination device must have space for the entire size of the virtual disk, even if it is mostly free space, as the complete contents of the source disk are copied.

Caution: The `vmkfstools` command may fail when attempting to import plain disks created with version 2.5 or earlier of GSX Server. If `vmkfstools` returns an error when importing a plain disk, see Path Name Failures When Importing GSX Server Virtual Machines on page 70.

Lists the files on the file system on the specified device

```
-l --list
-h --human-readable
-M --verbosemappings
```

The output includes permissions, sizes and the last modification time for redo logs, virtual disk files, and swap files. You can use the `-h` option to print the sizes in an easier-to-read format; for example, 5KB 12.1MB, and so on.

(Advanced users only) The `-M` option lists the `vmhba` name that corresponds to each raw disk mapping.

Sets the name of the VMFS on the specified SCSI device

```
-S --setfsname <fsName>
```

You can see the VMFS name by running the `vmkfstools` command with the `-l` option, `vmkfstools -l`.

Advanced vmkfstools Options

Advanced options are tasks that you may perform infrequently. These tasks are not available through the management interface, or are available in a limited form, and are suggested for advanced users only.

Commits the redo log of the specified file, making the associated changes permanent

```
-m --commit
```

If a virtual machine is in undoable or append mode, then the redo log is created automatically. The name of the redo log is derived by appending `.REDO` to the name of the file that contains the base disk image. You can commit the changes to the disk that are stored in the redo log by using the `commit` option or eliminate the changes by using the `rm` command to delete the redo-log file.

Sets the VMFS on the specified SCSI device to the specified mode

```
-F --config [public|shared|writable]
```

Note: In ESX Server 2.1, private VMFS volumes are deprecated. If you have existing VMFS version 1 (VMFS-1) or VMFS version 2 (VMFS-2) private volumes, then change the access to public.

Public — With public VMFS-2 volumes, multiple ESX Server computers can access the same VMware ESX Server VMFS volume concurrently. VMware ESX Server file systems with a public access mode use an automatic per-file locking to ensure file system consistency.

With a public VMFS-1 volume, multiple ESX Server computers have the ability to access the VMware ESX Server VMFS volume, as long as the VMFS volume is on a shared storage system (for example, a VMFS on a storage area network). However, only one ESX Server can access the VMFS-1 volume at a time.

Note: ESX Server creates VMFS volumes as public by default.

Shared — The shared access mode allows virtual machines on multiple servers to access the same virtual disk on a VMFS-2 volume simultaneously. (In public mode, virtual machines can only access the same VMFS volume, never the same virtual disk, at the same time.)

Note: A VMFS volume that is used for failover-based clustering should have its mode set to shared.

Writable — When virtual machines access a file on a shared VMFS, the file system metadata becomes read-only. That is, no virtual machine or user command can create, delete or change the attributes of a file.

If you need to create, remove, or change the length of a file (`vmkfstools -X`), then you need to change the volume to "writable". First, be sure that no virtual machines are accessing the VMFS volume (all virtual machines are powered off or suspended), then change the file system metadata to writable with the command, `vmkfstools --config writable`. Once you power on or resume a virtual machine, the file system metadata reverts to being read-only.

Extends an existing logical VMFS-2 volume by spanning multiple partitions

```
-Z --extendfs <extension-SCSIDevice>
-n --numfiles #
```

This option adds another physical extent (designated by `<extension-SCSIDevice>`), starting at the specified SCSI device. By running this option, you lose all data on `<extension-SCSIDevice>`.

Note: A logical VMFS-2 volume can have at most 32 physical extents.

This operation is not supported on the VMFS-1 file system and in fact, returns an error if the specified SCSI device is formatted as VMFS-1. Each time you use this option and extend a VMFS-2 volume with a physical extent, the VMFS volume supports, by default, an additional 64 files. You can change this default number of files by using the `-n` option.

Maps a Raw Disk or Partition to a File on a VMFS-2 Volume

```
-r --maprawdisk <raw-SCSI-device>
```

Once this mapping is established, you can access the raw disk like a normal VMFS file. The file length of the mapping is the same as the size of the raw disk or partition. The mapping can be queried for the raw SCSI device name by using the `-P` option.

By mapping a raw disk or partition to a file, you can manipulate this raw disk or partition as any other file. In addition, this mapping enables you to have undoable, append, and nonpersistent "raw disks".

All VMFS-2 file-locking mechanisms apply to raw disks.

Displays Disk Geometry for a VMware Workstation or GSX Server Virtual Disk

```
-g -- geometry <virtual-disk>
```

The output is in the form: `Geometry information C/H/S is 1023/128/32`, where `C` represents the number of cylinders, `H` represents the number of heads, and `S` represents the number of sectors.

When importing VMware Workstation or VMware GSX virtual disks to VMware ESX Server, you may see a disk geometry mismatch error message. A disk geometry mismatch may also be the cause if you have problems loading a guest operating system, or running a newly created virtual machine.

View the events log through the VMware Management Interface (Users and Events page for the virtual machine) or through the service console (the `vmware.log` file, found, by default, in the `<user>/vmware/<guest_operating_system>` directory). Look for `C/H/S` and compare this with the output of the `vmkfstools -g` command.

If the disk geometry information is different, then specify the correct information, from the output of the `vmkfstools -g` command, in the configuration file of the newly created virtual machine.

See Migrating VMware Workstation and VMware GSX Server Virtual Machines on page 67 for complete details on specifying the disk geometry in a virtual machine's configuration file.

Extends the specified VMFS to the specified length

```
-X --extendfile #[gGmMkK]
```

Use this command to extend the size of a disk allocated to a virtual machine, after the virtual machine has been created. The virtual machine that uses this disk file must be powered off when you enter this command. Also, the guest operating system must be able to recognize and use the new size of the disk, for example by updating the file system on the disk to take advantage of the extra space.

You specify the size in kilobytes, megabytes, or gigabytes by adding a suffix of `k` (kilobytes), `m` (megabytes), `g` (gigabytes) respectively.

Manages SCSI reservations of physical targets or LUNs

```
-L --lock [reserve|release|reset]
```

Caution: Be careful when using these commands. The `reserve`, `release`, and `reset` commands can interrupt the operations of other servers on a storage area network (SAN), so use these commands with great caution.

The `-L reserve` command reserves the specified raw disk, or the disk containing the specified VMFS volume. After the reservation, other servers will get a SCSI reservation error if they attempt to access that disk, but the server that did the reservation will be able to access the disk normally.

The `-L release` command releases the reservation on the specified disk, or disk containing the specified VMFS volume. Any other server can access the disk again.

The `-L reset` command does a SCSI reset to the specified disk. Any reservation held by another server is released.

Recovers a VMFS

```
-R --recover
```

This command enables you to recover a VMFS (accessible by multiple ESX servers) when other `vmkfstools` commands indicate that the file system is locked by another ESX Server machine, but, in fact, no other server is currently accessing this file system. This situation may occur if the VMFS was being accessed by a server (for example, running a virtual machine) and that server crashed.

Note: You should only use this command if you are certain that no other ESX Server is still accessing the file system.

Scans the specified vmhba adapter for devices and LUNs

```
-s --scan <FC_SCSI_adapter>
```

This option is particularly useful for adapters connected to storage area networks, particularly if you are reconfiguring your SAN. If a new device or LUN becomes accessible through the adapter, then ESX Server registers this new virtual device for use by virtual machines. If an existing device or LUN is no longer used and appears to be gone, then it is removed from use by virtual machines.

Note: Only use this `-s` option for Fibre Channel adapters.

You can see the results of the scan by using `ls /vmfs` or looking at the contents of `/proc/vmware/scsi`.

Create or Resize a Swap File in a VMFS Volume of the specified SCSI device

```
-k --createswapfile #[gGmMkK]
```

The size is specified in bytes by default, but you can specify the size in kilobytes, megabytes, or gigabytes by adding a suffix of `k` (kilobytes), `m` (megabytes), or `g` (gigabytes), respectively.

Note: You must be logged in to the Service Console with `root` user permissions to create a swap file.

You can resize an existing swap file by specifying the new file size as an argument to the `-k` option:

1. Deactivate the swap file, if it is active, with `vmktools -y`.
2. Resize the swap file with the `-k` option.
3. Activate the swap file with `vmktools -w filename`.

If you try to resize an active swap file, ESX Server returns an error message.

ESX Server does not automatically activate a swap file after it is created. Use `vmkfstools` with the `-w` option to activate a swap file. You can set a swap file to be activated automatically after a system reboot with the **Activation Policy** option of the **Swap Management** section in the **Options** tab of the Management Interface.

Activate a Swap File

```
-w --activateswapfile
```

This command activates the specified swap file.

Note: You must be logged in to the Service Console with `root` user permissions to activate a swap file.

Deactivate a Swap File

```
-y --deactivateswapfile <fileID>
```

ESX Server assigns a `fileID` tag to a swap file when it is activated. You must identify a swap file by its `fileID` tag when specifying which swap file to deactivate with the `-y` option.

Note: You must be logged in to the Service Console with `root` user permissions to activate a swap file.

You can find the `fileID` tag assigned to a swap file in the swap status file, `/proc/vmware/swap/stats`.

Note: You must shutdown all virtual machines before deactivating a swap file. Entering a `vmkfstools -y` command returns an error message if any virtual machines are powered on.

Migrate a VMFS from VMFS-1 to VMFS-2

```
-T --tovmfs2
```

This command converts the VMFS volume on the specified partitions from VMFS-1 to VMFS-2, while preserving all files in the volume. ESX Server's locking mechanism attempts to ensure that no remote ESX Server or local process is accessing the VMFS volume that is being converted.

Note: If you have an active swap partition, you must deactivate it before running this command. Deactivate swap through the VMware Management Interface and reboot your server. Once this `vmkfstools -T` command completes, you can reactivate your swap file.

This conversion may take several minutes. When your prompt returns, the conversion is complete.

Note: In ESX Server 2.1, private VMFS volumes are deprecated. If you have an existing VMFS version 1 (VMFS-1) private volume, then the newly created VMFS-2 volume's access mode is automatically changed to public.

Before starting this conversion, check the following:

- Back up the VMFS-1 volume that is being converted
- Be sure there are no virtual machines powered on using this VMFS-1 volume
- (SAN only) Be sure no other ESX Server is accessing this VMFS-1 volume
- (SAN only) Be sure this VMFS-1 volume is not mounted on any other ESX Server

Caution: The VMFS-1 to VMFS-2 conversion is a one-way process. Once the VMFS volume is converted to VMFS-2, you *cannot* revert it back to a VMFS-1 volume.

Note: The first time you access a newly converted VMFS-2 volume, the initial access will be slow, because of internal volume consistency checking.

Examples Using vmkfstools

This section includes examples using the `vmkfstools` command with the different options described previously.

Create a new file system

```
vmkfstools -C vmfs2 -b 2m -n 32 vmhba1:3:0:1
```

This example illustrates creating a new VMFS version 2 (`vmfs2`) on the first partition of target 3, LUN 0 of SCSI adapter 1. The file block size is 2MB and the maximum number of files is 32.

Extends the new logical volume by spanning two partitions

```
vmkfstools -Z vmhba0:1:2:4 vmhba1:3:0:1
```

This example illustrates extending the new logical file system by adding the 4th partition of target 1 (and LUN 2) of `vmhba` adapter 0. The extended file system supports a maximum of 64 (2 X 32) files, and spans two partitions — `vmhba1:3:0:1` and `vmhba0:1:2:4`.

You can address the file system by using the name of its head partition; for example, `vmhba1:3:0:1`.

Names a VMFS volume

```
vmkfstools -S mydisk vmhba1:3:0:1
```

This example illustrates assigning the name of `mydisk` to the new file system.

Creates a new VMFS virtual disk file

```
vmkfstools -c 2000m mydisk:rh6.2.dsk
```

This example illustrates creating a 2GB VMFS file with the name of `rh6.2.dsk` on the VMFS volume named `mydisk`. The `rh6.2.dsk` file represents an empty disk that may be accessed by a virtual machine.

Imports the contents of a virtual disk to the specified file on a SCSI device

```
vmkfstools -i ~/vms/nt4.dsk vmhba0:2:0:0:nt4.dsk
```

The example illustrates importing the contents of a virtual disk (that contains Windows NT 4.0) from the service console's file system to a file named `nt4.dsk` on target 2 of SCSI adapter 0.

You can configure a virtual machine to use this virtual disk by adding the following lines to its configuration file:

```
scsi0.virtualDev = vmxbuslogic
scsi0:0.present = TRUE
scsi0:0.name = vmhba0:2:0:0:nt4.dsk
```

Migrate virtual machines to VMware GSX Server or VMware Workstation, then back to VMware ESX Server

Note: The following example, illustrating the `-e` and `-i` options, result in the export or import of a virtual disk.

This example illustrates migrating a virtual machine's virtual disk file from ESX Server to VMware GSX Server or VMware Workstation, then migrating the virtual disk back to ESX Server.

```
vmkfstools -e winXP.vmdk vmhba0:6:0:1:winXP.dsk
```

The preceding command exports the `winXP.dsk` virtual disk file to one or more `.vmdk` files, maximum size 2GB, that you can use as a virtual disk in a virtual machine on GSX Server or Workstation. The resultant `winXP.vmdk` file(s) can reside on a VMFS volume, or an `/ext2`, `/ext3`, or NFS file system.

The following example imports a GSX Server or Workstation virtual disk file into the VMFS volume on the specified SCSI device.

```
vmkfstools -i winXP.vmdk vmhba0:6:0:1:winXP.dsk
```

By contrast, if you are importing directly into a raw partition, the example becomes:

```
vmkfstools -i winXP.vmdk vmhba0:6:0:1
```

Lists the files on the VMFS of the specified device

```
vmkfstools -l vmhba0:2:0:0
```

This command illustrates listing the contents of the file system, including redo logs, virtual disk files, and swap files on target 2 of SCSI adapter 0.

Scans a vmhba adapter

This example illustrates scanning the `vmhba1` adapter for any new or removed targets or LUNs.

```
vmkfstools -s vmhba1
```

Accessing Raw SCSI Disks

You can access raw disks directly or use the vmkfstools -r command to map them to files on VMFS-2 volumes. Once this mapping is established, you access the raw disk or partition like a normal file. For more information on this mapping, see Using vmkfstools on page 296, in particular, the `vmkfstools -r` option.

Using a Physical Disk in a Virtual Machine

In order for the virtual machine to access a physical disk or LUN, you must add the disk to the virtual machine. This example assumes that the virtual machine's first disk is a virtual disk and you are adding the physical disk as the second disk.

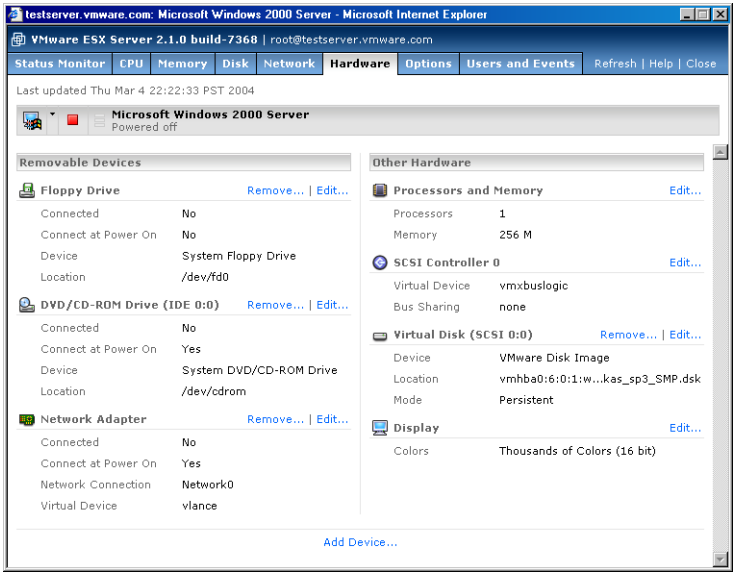
If you want the virtual machine's first disk to be a physical disk, see Creating a New Virtual Machine on page 38 and select **System LUN/Disk** for your virtual disk.

1. Log into the VMware Management Interface as the user who owns the virtual machine or as the root user.

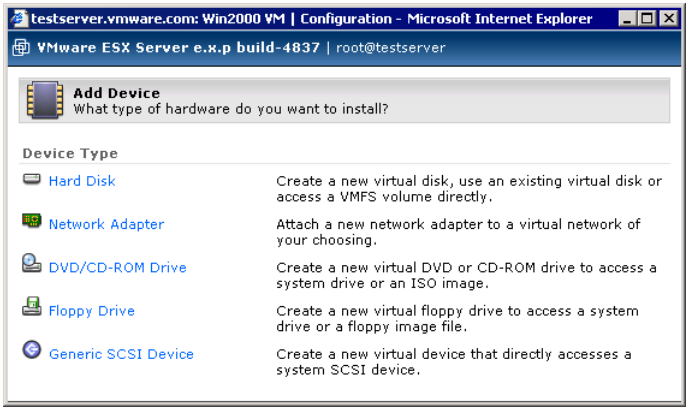
   The Status Monitor page appears.

2. Click the arrow to the right of the terminal icon ( ) for the virtual machine you want to change and choose **Configure Hardware**.

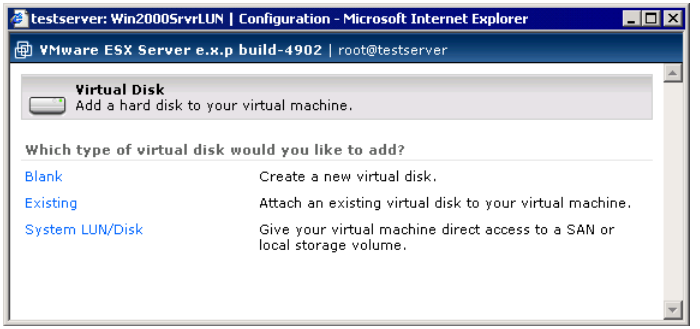
   The Hardware page for this virtual machine appears in a new browser window.



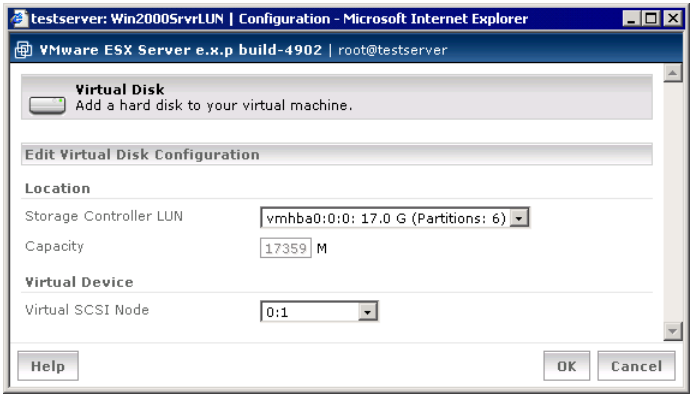
3. Click **Add Device**. The Add Device Wizard starts.


testserver.vmware.com: Win2000 VM | Configuration - Microsoft Internet Explorer
VMware ESX Server e.x.p build-4837 | root@testserver
Add Device
What type of hardware do you want to install?
Device Type
Hard Disk
Create a new virtual disk, use an existing virtual disk or access a VMFS volume directly.
Network Adapter
Attach a new network adapter to a virtual network of your choosing.
DVD/CD-ROM Drive
Create a new virtual DVD or CD-ROM drive to access a system drive or an ISO image.
Floppy Drive
Create a new virtual floppy drive to access a system drive or a floppy image file.
Generic SCSI Device
Create a new virtual device that directly accesses a system SCSI device.

4. Click **Hard Disk**. The Virtual Disk Type page appears.


testserver: Win2000SrvrLUN | Configuration - Microsoft Internet Explorer
VMware ESX Server e.x.p build-4902 | root@testserver
Virtual Disk
Add a hard disk to your virtual machine.
Which type of virtual disk would you like to add?
Blank
Create a new virtual disk.
Existing
Attach an existing virtual disk to your virtual machine.
System LUN/Disk
Give your virtual machine direct access to a SAN or local storage volume.

5. Click **System LUN/Disk** to allow the virtual machine to access a physical disk stored on a LUN. Then specify the following.



6. Choose the LUN you want to use in the **Storage Controller LUN** list.
7. Specify the virtual device node. Select the appropriate SCSI ID in the **Virtual SCSI Node** list.
8. Click **OK** to add the disk.

Determining SCSI Target IDs

In order to assign SCSI disks to a virtual machine, you need to know which controller the drive is on and what the SCSI target ID of the controller is. This section helps you determine these values without opening your computer and physically looking at the SCSI target ID settings on the drives.

SCSI disks may be accessed by local SCSI adapters, or on a SAN by Fibre Channel adapters. Therefore, whenever we describe SCSI adapters in this section, these descriptions also apply to Fibre Channel adapters, even though they are not explicitly mentioned.

On a standard Linux system, or for a VMware service console that has SCSI or Fibre Channel (FC) controllers assigned to the service console rather than the VMkernel, information on attached SCSI devices, including SCSI target IDs is available in the boot log (usually `/var/log/messages`), or from examining `/proc/scsi/scsi`.

Information about the SCSI controllers assigned to the VMkernel and about the devices attached to these controllers is available in the `/proc/vmware/scsi` directory once the VMkernel and the VMkernel device module(s) for the SCSI controller(s) have been loaded.

Each entry in the `/proc/vmware/scsi` directory corresponds to a SCSI controller assigned to the VMkernel. For example, assume you issued a `vmkload_mod` command with the base name `vmhba` and a single SCSI controller was found.

To identify the controller, type this command:

```
ls -l /proc/vmware/scsi
```

The output of the `ls` command is:

```
total 0
dr-xr-xr-x 2 root    root        0 Jun 22 12:44 vmhba0
```

Each SCSI controller's subdirectory contains entries for the SCSI devices on that controller, numbered by SCSI target ID and LUN (logical unit number). Run `cat` on each target ID:LUN pair to get information about the device with that target ID and LUN. For example, type this command:

```
cat /proc/vmware/scsi/vmhba0/1:0
```

The following information is displayed:

```
Vendor: SEAGATE Model: ST39103LW  Rev: 0002
Type: Direct-Access   ANSI SCSI revision: 02
Size: 8683 Mbytes
Queue Depth: 28
```

```
Partition Info:
Block size: 512
Num Blocks: 17783240

     num: Start     Size Type
     4:   1  17526914 fb

Partition 0:
    VM   11
    Commands  2
    Kbytes read 0
    Kbytes written 0
    Commands aborted 0
    Bus resets  0
Partition 4:
    Commands  336
    Kbytes read 857
    Kbytes written 488
    Commands aborted 0
    Bus resets  0
```

This information should help you determine the SCSI target ID to use in the storage configuration page, as displayed by the VMware Management Interface. See Configuring Storage: Disk Partitions and File Systems on page 233.

Sharing the SCSI Bus

Normally, VMware ESX Server enforces locking and does not allow two virtual machines to access the same virtual disk (VMFS file) at the same time. If a second virtual machine tries to access a VMFS file, it gets an error and does not power on.

However, it is often useful to have more than one virtual machine share a disk in order to provide high availability. This configuration is commonly used for disk-based failover, in which one machine takes over running an application when the primary machine fails. The data required for the application is typically stored on a shared disk, so the backup machine can immediately access the necessary data when the failover occurs. See Configuration for Clustering on page 329 for complete information on clustering with ESX Server.

The bus sharing setting is used to determine if virtual machines are allowed to access the same virtual disk simultaneously.

Setting Bus Sharing Options

Use the VMware Management Interface to change the bus sharing settings for each virtual machine that will access the same virtual disk simultaneously.

There are three bus sharing options.

- **None**: Disks cannot be shared by other virtual machines
- **Virtual**: Disks can be shared by virtual machines on same server
- **Physical**: Disks can be shared by virtual machines on any server

To enable sharing of virtual disks, choose **Virtual** or **Physical**. All virtual disks on the specified virtual bus will be sharable and have the specified mode.

If the bus sharing is **Virtual**, only virtual machines on the same physical machine will be able to share disks. This setting allows for a "cluster-in-a-box" configuration, in which all members of a high-availability cluster are on the same physical machine. This setup is useful for providing high availability when the likely failures are due to software or administrative errors.

If the bus sharing is **Physical**, virtual machines on different physical machines will be able to share disks. In this case, the VMFS holding the virtual disks must be on a physically shared disk, so all of the physical machines can access it. This setup is useful for providing high availability when the likely failures also include hardware errors.

When a shared disk is used for high availability purposes, the current machine that is running the application and using the shared data often reserves the disk using a SCSI command.

Also, if the bus sharing is **Physical**, commands that reserve, reset or release a shared virtual disk are transmitted through to the physical disk, so other machines sharing the disk can properly detect when a virtual disk has been reserved or reset. Therefore, when you are sharing disks among virtual machines across physical machines for high availability purposes, it is often best to put only a single VMFS with a single virtual disk on each shared disk — that is, have only one virtual disk per physical disk. In such a configuration, each virtual disk can be reserved and released independently.

To change the bus sharing setting, complete the following steps:

1. Log into the management interface as the appropriate user and be sure the virtual machine you want to configure is powered off.
2. Point to the terminal icon for the virtual machine you want to configure and click **Configure Hardware.**
3. Click **Edit** next to the appropriate SCSI controller.
4. Choose the bus sharing setting you want from the drop-down list, then click **OK**.

Using Storage Area Networks with ESX Server

VMware ESX Server can be used effectively with storage area networks (SANs). ESX Server supports Qlogic and Emulex host bus adapters, which allow an ESX Server computer to be connected to a SAN and to see the disk arrays on the SAN.

The SCSI configuration information contained in this section also applies to Fibre Channel adapters, but note that FC adapters may require additional configuration as well.

For information on supported SAN hardware, download the VMware ESX Server SAN Compatibility List from the VMware Web site at *www.vmware.com/support/esx2*.

Understanding Storage Arrays

Large storage systems (also known as disk arrays) combine numerous disks into arrays for availability and performance. Typically, a collection of disks is grouped into a Redundant Array of Inexpensive Disks (RAID) array to protect the data by eliminating disk drives as a potential single point of failure.

Disk arrays carve the storage RAID set into logical units (LUNs) that are presented to the server in a manner similar to an independent single disk. Typically, LUNs are few in number, relatively large, and fixed in size.

You can create LUNs with the storage management application of your disk array.

Installing ESX Server with Attached SANs

We recommend that you install ESX Server software on a local SCSI disk.

Caution: Be sure that all Fibre Channel adapters (QLogic or Emulex) are detached from the SAN during ESX Server installation. If they are not disconnected, SAN disks are often displayed first in the list of drives displayed during installation. This may cause confusion when the service console is being installed.

In addition, we recommend that all Fibre Channel adapters are dedicated exclusively for the virtual machines. Even though these FC adapters are dedicated to virtual machines, the LUNs on the SANs are visible to system management agents on the service console.

Configuring VMFS Volumes on SANs

Be sure that only one ESX Server has access to the SAN while you are using the VMware Management Interface to configure the SAN and format the VMFS-2 volumes. After you have finished the configuration, be sure that all partitions on the physically shared SAN disk are set for public or shared access for access by multiple ESX Servers (see VMFS Accessibility on page 294).

For information on configuring SANs, scanning for LUNs and setting persistent bindings through the VMware Management Interface, see Configuring Storage Area Networks on page 232.

Scanning for Devices and LUNs

ESX Server scans for devices, and LUNs on these devices, whenever a Fibre Channel driver is loaded. You can manually initiate a scan through the VMware Management Interface or by using the `vmkfstools -s` command.

You may want to rescan devices or LUNs whenever you add a new disk array to the SAN or create new LUNs on a disk array. You may also want to rescan LUNs when you change the LUN masking on a disk array.

Note: For QLogic adapters, you must do one additional step before scanning, in order to recognize new LUNs on existing disk arrays. For each and every numeric entries in `/proc/scsi/qla2200` or `/proc/scsi/qla2300`, run the appropriate command, as the root user, on the service console:

```
echo "scsi-qlascan" > /proc/scsi/qla2200/<numeric_entry>
```

or

```
echo "scsi-qlascan" > /proc/scsi/qla2300/<numeric_entry>
```

These commands tell the QLogic driver to clear its cache of existing LUNs.

Caution: Do not run the `vmkfstools -s` command on non-Fibre Channel adapters.

Type the following command to scan for devices or LUNs through a particular FC SCSI adapter:

```
vmkfstools -s <FC_SCSI_adapter>
```

For example, if you wanted to rescan SCSI adapter `vmhba0` for new (and removed) devices or LUNs, type:

```
vmkfstools -s vmhba0
```

For more information on using vmkfstools, see Using vmkfstools on page 296.

Note: If you are using multipathing with multiple FC HBAs, then you should run this command on all of the FC HBAs. If, after your rescan, you see new LUNs and they have VMFS volumes, then you will see the appropriate subdirectories when you view the contents of the `/vmfs` directory.

Choosing QLogic Adapters

If you are using a QLogic storage adapter, then be sure to choose the right driver version:

- IBM storage — QLogic driver version 6.04 (default)
- HP storage — QLogic driver version 6.04 (default)
- EMC storage — QLogic driver version 6.04 (default)

Changing VMkernel Configuration Options for SANs

In order to use all storage devices on your SAN, you may need to change some VMkernel configuration options as described below.

To make these changes, complete the following steps.

1. Log in to the VMware Management Interface as root.

   The Status Monitor page appears.

2. Click the **Options** tab.
3. Click **Advanced Settings**.
4. To change an option, click the current value, then enter the new value in the dialog box and click **OK**.

   For more information on changing these settings, see Changing Advanced Settings on page 242.

Detecting All LUNs

By default, the VMkernel scans for only LUN 0 to LUN 7 for every target. If you are using LUN numbers larger than 7 you must change the setting for the DiskMaxLUN field from the default of 8 to the value that you need. For example, if you now have LUN numbers 0 to 15 active, set this option to 16. Currently, an ESX Server machine can see a maximum of 128 LUNs over all disk arrays on a SAN.

By default, the VMkernel is configured to support sparse LUNs — that is, a case where some LUNs in the range 0 to N-1are not present, but LUN N is present. If you do not need to use such a configuration, you can change the DiskSupportSparseLUN field to 0. This change decreases the time needed to scan for LUNs.

The DiskMaskLUNs configuration option allows the masking of specific LUNs on specific HBAs. Masked LUNs are not touched or accessible by the VMkernel, even during initial scanning. The DiskMaskLUNs option takes a string comprised of the adapter name, target ID and comma-separated range list of LUNs to mask. The format is as follows:

```
<adapter>:<target>:<comma_separated_LUN_range_list>;
```

For example, you want to mask LUNs 4, 12, and 54-65 on `vmhba` 1 target 5, and LUNs 3-12, 15, and 17-19 on `vmhba` 3 target 2. To accomplish this, set the DiskMaskLUNs option to the following:

```
"vmhba1:5:4,12,54-65;vmhba3:2:3-12,15,17-19;"
```

Note: LUN 0 cannot be masked.

The DiskMaskLUNs option subsumes the DiskMaxLUN option for adapters that have a LUN mask. In other words, continuing the preceding example, there are four adapters, `vmhba0`, `vmhba1`, `vmhba2`, and `vmhba3`, and the DiskMaxLUN option is set to 8. In this example, `vmhba0` and `vmhba2` only scan LUNs 0-7, but `vmhba1` and `vmhba3` scan all LUNs that are not masked, up to LUN 255, or the maximum LUN setting reported by the adapter, whichever is less.

For administrative or security purposes, you can use LUN masking to prevent the server from seeing LUNs that it doesn't need to access. Refer to your documentation on disk arrays for more information.

Using IBM FAStT Disk Arrays

An IBM FAStT disk array sometimes returns vendor-specific status codes that ESX Server interprets as errors. These status codes are temporary -- indicating, for example, that the firmware has been upgraded or that the battery for the disk cache needs to be charged. ESX Server, in its default configuration, may interpret these status codes to mean that a LUN exists but is not accessible.

You avoid this problem by using a special ESX Server configuration option. Log in to the management interface as the root user, click **Advanced Settings**, then click **VMkernel Configuration**. Find the option `DiskRetryUnitAttention` and be sure that it is enabled (the default).

With this option enabled, ESX Server automatically retries SCSI commands when these vendor-specific status codes are received.

Troubleshooting SAN Issues with ESX Server

You can view LUNs through the VMware Management Interface or viewing the output of `ls /proc/vmware/scsi/<FC_SCSI_adapter>`. If the output differs from what you expect, then check the following:

- DiskMaxLUN — the maximum number of LUNs per `vmhba` that are scanned by ESX Server.

  You can view and set this option through the VMware Management Interface (Advanced Settings in the Options page) or by viewing this setting through `/proc/vmware/config`.

- DiskSupportSparseLUN — if this option is on, then ESX Server scans past any missing LUNs. If this option is off, ESX Server stops scanning for LUNs if any LUN is missing.

  You can view and set this option through the VMware Management Interface (Advanced Settings in the Options page) or by viewing this setting through `/proc/vmware/config`.

- LUN masking — With LUN masking, each LUN is exclusively assigned and accessed by a specific list of connections. Be sure that LUN masking is implemented properly and that the LUNs are visible to the HBAs on ESX Server.

- Zoning — Zoning limits access to specific storage devices and increases security and decreases traffic over the network. If you use zoning, be sure that zoning on the SAN switch is set up properly and that all `vmhba` and the controllers of the disk array are in the same zone.

- Storage controller — If a disk array has more than one storage controller, then make sure that the SAN switch has a connection to the controller that owns the LUNs you wish to access. On some disk arrays, only one controller is "active" and the other controller is "passive" until there is a failure. If you are connected to the wrong controller, then you may not see the expected LUNs, or you may see the LUNs, but may get errors when trying to access them.

For more information on using SANs with ESX Server, be sure to check the Knowledge Base on the VMware Web site at *www.vmware.com/support/*.

Using Persistent Binding

You can specify persistent bindings for your Fibre Channel host bus adapters (HBAs). With persistent binding, ESX Server assigns specific target IDs to specific Fibre Channel SCSI devices. This target ID association is retained from reboot to reboot unless changed by you.

Persistent binding is particularly useful if you are using raw disks with ESX Server. A raw disk is directly mapped to a LUN or physical disk drive on your storage area network (SAN). ESX Server directly accesses the data on this disk as a raw device (and not as a file on a VMFS volume).

You can persist bindings through the VMware Management Interface or through the service console. For complete information on persisting bindings through the management interface, see Configuring Storage Area Networks on page 232.

Determining Target IDs through the Service Console

If you prefer to use the service console, type `cat /proc/scsi/<FC_SCSI_driver>/<adapter_number>` to determine the target IDs.

Example Output for an Emulex HBA

```
#cat /proc/scsi/<FC_SCSI_driver>/<adapter_number>

.
.
.
Portname: 10:00:00:00:c9:32:23:49   Nodename:
20:00:00:00:c9:32:23:49

Link Up - Ready:

  PortID 0x21900
  Fabric
  Current speed 1G

lpfc0t00 DID 021500 WWPN 20:00:00:60:16:3c:ad:13 WWNN
20:00:00:60:16:3c:ad:13
```

where:

`Portname: 10:00:00:00:c9:32:23:49`	Adapter port name
`Nodename: 20:00:00:00:c9:32:23:49`	Adapter node name
`lpfc0t00`	`0` (`lpfc0`) is the host bus adapter and `00` is the target
`WWPN 20:00:00:60:16:3c:ad:13`	Target world wide port name (WWPN)
`WWNN 20:00:00:60:16:3c:ad:13`	Target world wide node name (WWNN)

Example Output for a QLogic HBA

```
#cat /proc/scsi/<FC_SCSI_driver>/<adapter_number>
.
.
.
SCSI Device Information:
scsi-qla0-adapter-node=200100e08b229b53;
scsi-qla0-adapter-port=210100e08b229b53;
scsi-qla0-target-0=20000060163cad13;
.
.
.
```

where:

`200100e08b229b53`	Adapter world wide port name (`adapter-port`)
`210100e08b229b53`	Adapter world wide node name (`adapter-node`)
`qla0`	`0` is the host bus adapter
`target-0`	`0` is the target
`20000060163cad13`	World wide port name

pbind.pl Script

The `pbind.pl` script is located in the `/usr/sbin` directory. As root, type `pbind.pl` to see the list of options for this command.

pbind.pl Option	Description
`pbind.pl -A`	Persists bindings for all adapters.
`pbind.pl -D`	Deletes bindings for all adapters.
`pbind.pl -a <path>`	Adds bindings for all adapters specified in `<path>`.
`pbind.pl -d <path>`	Deletes bindings for all adapters specified in `<path>`.
`pbind.pl -r`	Shows you the result without actually making any change.
`pbind.pl -s`	Displays supported adapters and their paths.
`pbind.pl -q`	Quiet mode; suppresses normal status output.

Examples Using the pbind.pl Script

This example adds bindings for all QLogic 2200 hosts.

```
pbind.pl -a /proc/scsi/qla2200/
```

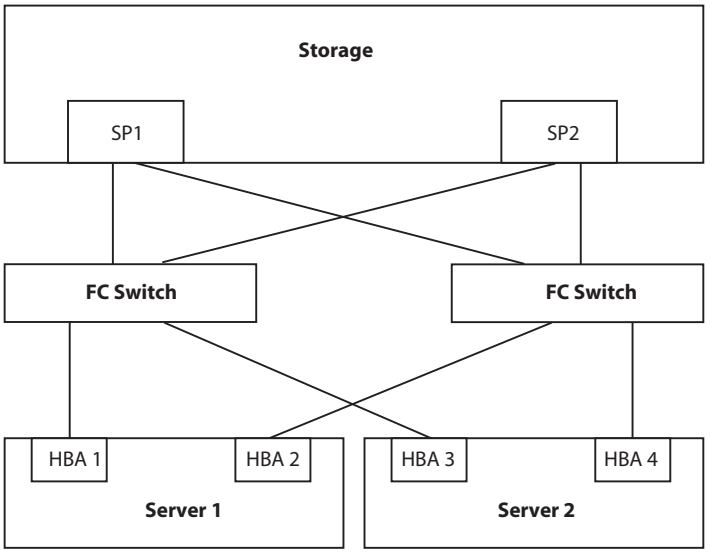
This example adds binding for QLogic 2200 host 2.

```
pbind.pl -a /proc/scsi/qla2200/2
```

Note: Typing a wildcard character, for example, `pbind.pl -a /proc/scsi/qla2200/*` is invalid.

Using Multipathing in ESX Server

ESX Server 2.1 includes multipathing support to maintain a constant connection between the server machine and the storage device in case of the failure of a host bus adapter (HBA), switch, storage controller (or storage processor; abbreviated as SP in the following diagram), or a Fibre Channel cable. Unlike previous versions of ESX Server, this version of multipathing support does not require specific failover drivers.



In the preceding diagram, there are multiple, redundant paths from each server to the storage device. For example, if HBA1, or the link between HBA1 and the Fibre Channel (FC) switch breaks, HBA2 takes over and provides the connection between the server and the switch. This process is called HBA failover.

Similarly, if SP1, or the link between SP1 and the switch breaks, SP2 takes over and provides the connection between the switch and the storage device. This process is called SP failover. VMware ESX Server 2.1 provides both HBA and SP failover with its multipathing feature. (SP failover may not be supported by all disk arrays.)

For information on supported SAN hardware, download the VMware ESX Server SAN Compatibility List from the VMware Web site at *www.vmware.com/support/esx2*.

Choosing Path Management Tools

ESX Server allows you to configure and manage multipath access to storage devices through both the Management Interface and the Service Console. The sections below describe how to manage multipathing in the Service Console with the `vmkmultipath` command. For instructions on configuring multipathing with the Management Interface, seeViewing Failover Paths Connections on page 239.

Viewing the Current Multipathing State

You can view your current multipathing configuration with the `vmkmultipath -q` command. The `-q` option displays the state of all or selected paths recognized by ESX Server. The report displayed by `vmkmultipath` shows the current multipathing policy for a disk and the connection state and mode for each path to the disk.

The report identifies disks by their canonical name. The canonical name for a disk is the first path ESX Server finds to the disk. Since ESX Server begins its scans at the first controller and the lowest device number, the first path (and thus the canonical name of the disk) is the path with the lowest number controller and device number. For example, if the paths to a disk are `vmhba0:0:2`, `vmhba1:0:2`, `vmhba0:1:2` and `vmhba1:1:2`, then the canonical name of the disk is `vmhba0:0:2`.

To see a report for all disks, enter:

```
# vmkmultipath -q
```

Below is a typical report displayed for a configuration of ESX Server managing a SAN:

```
Disk and multipath information follows:

Disk vmhba0:0:1 (34,326 MB) has 6 paths.  Policy is fixed.
vmhba0:0:1       on  (active, preferred)
vmhba0:1:1       on
vmhba0:2:1       on
vmhba1:0:1       on
vmhba1:1:1       on
vmhba1:2:1       on

Disk vmhba0:0:2 (100,319 MB) has 6 paths.  Policy is fixed.
vmhba0:0:2       on  (active, preferred)
vmhba0:1:2       on
vmhba0:2:2       on
vmhba1:0:2       on
vmhba1:1:2       on
vmhba1:2:2       on

Disk vmhba0:0:4 (0 MB) has 6 paths.  Policy is fixed.
vmhba0:0:4       on  (active, preferred)
vmhba0:1:4       on
```

```
vmhba0:2:4       on
vmhba1:0:4       on
vmhba1:1:4       on
vmhba1:2:4       on

Disk vmhba0:0:6 (0 MB) has 6 paths.  Policy is fixed.
vmhba0:0:6       on  (active, preferred)
vmhba0:1:6       on
vmhba0:2:6       on
vmhba1:0:6       on
vmhba1:1:6       on
vmhba1:2:6       on

Disk vmhba0:3:3 (0 MB) has 2 paths.  Policy is mru.
vmhba0:3:3       on  (active, preferred)
vmhba1:3:3       on
```

In this system configuration, the disk `vmhba0:0:2` has a "fixed" policy. There are six paths to the disk recognized by ESX Server. The list of paths indicates the different physical routes by which the disk can be accessed.

The status of each path to the disk is indicated in the second column. The report lists each path as `on`, `off`, or `dead`:

- `on` indicates that the path is functional, and that data is being transferred successfully
- `off` indicates that this path has been deliberately turned off
- `dead` indicates that the path should be active, but the software cannot connect to the disk through this path

The report lists the mode of each path in the third column:

- `preferred` identifies the primary path ESX Server uses to access the disk
- `active` identifies the actual path used by ESX Server to access the disk

Note: Reports returned by `vmkmultipath` list paths to both physical disks and storage controllers. In the example above, the "disks" listed as having no space available are actually storage processors.

You can display the multipathing status for a single disk by specifying it in the query command. For example, to display the report for disk `vmhba0:0:6`, enter:

```
# vmkmultipath -q vmhba0:0:6
```

Setting Your Multipathing Policy for a LUN

You can specify the default policy for the multipathing feature. There are two policies:

- fixed — ESX Server always uses the preferred path to the disk; if it cannot access the disk through the preferred path, then it tries the alternate paths. Fixed is the default policy for active/active storage devices.

  Enter the following command to select the fixed policy for a disk, in this example, `vmhba0:0:0`.

  ```
  # vmkmultipath -s vmhba0:0:0 -p fixed
  ```

- mru — ESX Server uses the most recent path to the disk until this path becomes unavailable. That is, ESX Server does not automatically revert back to the preferred path. Most recent path (`mru`) is the default policy for active/passive storage devices.

  Enter the following command to select the mru policy for a disk, in this example, `vmhba0:0:0`.

  ```
  # vmkmultipath -s vmhba0:0:0 -p mru
  ```

Note: You can select a different policy for each disk.

Specifying Paths

You can use the `vmkmultipath` command to disable and enable paths, set the active path, and set the preferred path, as illustrated in the following examples. You configure paths by setting path modes with the `-s` option.

Enabling a Path

Use the `-e` option to enable paths with `vmkmultipath`. In this example, you are enabling the path from controller `vmhba1:0:1` to disk `vmhba0:0:1`.

```
# vmkmultipath -s vmhba0:0:1 -e vmhba1:0:1
```

Disabling a Path

Use the `-d` option to disable paths with `vmkmultipath`. In this example, you are disabling the path from controller `vmhba1:0:1` to disk `vmhba0:0:1`.

```
# vmkmultipath -s vmhba0:0:1 -d vmhba1:0:1
```

Setting the Preferred Path

Use the `-r` option to specify the preferred path to a disk. In this example, you are setting as preferred the path from controller `vmhba1:0:1` to disk `vmhba0:0:1`.

```
# vmkmultipath -s vmhba0:0:1 -r vmhba1:0:1
```

Note: ESX Server ignores the preferred path when the multipathing policy is set to `mru`.

Saving Your Multipathing Settings

Your multipathing settings are saved when shutting down ESX Server normally. However, we suggest you run the following command, as root, to ensure your settings are saved, in case of an abnormal shutdown.

```
# /usr/sbin/vmkmultipath -S
```

By running this command, your multipathing settings are restored automatically when you restart your system.

In Case of Failover

When a cable is pulled, I/O freezes for approximately 30-60 seconds, until the SAN driver determines that the link is down, and failover occurs. During that time, the virtual machines (with their virtual disks installed on a SAN) may appear unresponsive, and any operations on the `/vmfs` directory may appear to hang. After the failover occurs, I/O should resume normally.

Even though ESX Server's failover feature ensures high availability and prevents connection loss to SAN devices, all connections to SAN devices may be lost due to disastrous events, that include multiple breakages.

If all connections to the storage device are not working, then the virtual machines will begin to encounter I/O errors on their virtual SCSI disks. Also, operations in the `/vmfs` directory may eventually fail after reporting an "I/O error".

Settings for QLogic Adapters

For QLogic cards, you may want to adjust the `PortDownRetryCount` value in the QLogic BIOS. This value determines how quickly a failover occurs when a link goes down.

If the `PortDownRetryCount` value is `<n>`, then a failover typically takes a little longer than `<n>` multiplied by 2 seconds. A typical recommended value for `<n>` is 15, so in this case, failover takes a little longer than 30 seconds.

For more information on changing the `PortDownRetryCount` value, refer to your QLogic documentation.

Failover in Windows 2000 and Windows Server 2003 Guest Operating Systems
For the Windows 2000 and Windows Server 2003 guest operating systems, you may want to increase the standard disk TimeOutValue so that Windows will not be extensively disrupted during failover.

1. Select **Start > Run**, type `regedit.exe`, and click **OK**.
2. In the left panel hierarchy view, double-click **HKEY_LOCAL_MACHINE**, **System**, **CurrentControlSet**, **Services**, then **Disk**.
3. Select the `TimeOutValue` and set the Data value to `x03c` (hexadecimal) or `60` (decimal). By making this change, Windows waits at least 60 seconds, for delayed disk operations to complete, before generating errors.
4. Click **OK** and exit the **Registry Editor** program.

CHAPTER 10

Configuration for Clustering

ESX Server clustering capabilities are ideally suited for development, testing and training applications. Any clustering configuration based on ESX Server should not be deployed in a production environment unless it has been rigorously tested and reviewed.

The following sections outline how to use VMware ESX Server 2.1 and higher to provide clustered virtual machines in a variety of environments.

- What Is Clustering? on page 330
- Clustering Virtual Machines on page 332
- Network Load Balancing on page 351
- Guidelines for Specific Configurations on page 358

What Is Clustering?

Clustering is simply described as providing a service via a group of servers to get high availability, scalability or both.

For example, all nodes in a cluster serve a Web site that serves static content. The main gateway distributes requests to all nodes according to load. It redirects requests to remaining nodes if one crashes. This gives better availability and better performance. Network Load Balancing in Windows 200 provides such a service.

Another example of a more complex configuration: A single node serves a database. If that node crashes, the clustering software must restart the database on another node. The database application knows how to recover from a crash. In normal operation, other nodes are used for running other applications. Microsoft Cluster Service and Veritas Cluster Service provide such a service.

Applications that Can Use Clustering

To take advantage of clustering services, applications need to be clustering aware.

Such applications can be:

- Stateless, as Web servers and VPN servers are.
- With built-in recovery features, like those in database servers, mail servers, file servers or print servers.

Clustering Software

Available clustering software include:

- Microsoft Clustering Service (MSCS)

  Provides fail-over support for 2- to 8-node clusters for applications such as databases, file servers and mail servers

- Microsoft Network Load Balancing (NLB)

  Load balances incoming IP traffic across a cluster of nodes for applications such as Web servers and terminal services.

- Veritas Clustering Service (VCS)

Clustering Hardware

A typical clustering setup includes:

- Disks that are shared between nodes

  These are needed if the application uses dynamic data as mail servers or database servers do.

  The shared disks may be shared SCSI disks or a storage area network using Fibre Channel.

- Extra network connectivity between nodes for monitoring heartbeat status.
- A method for redirecting incoming requests.

Clustering Virtual Machines

Clustering Software in Virtual Machines

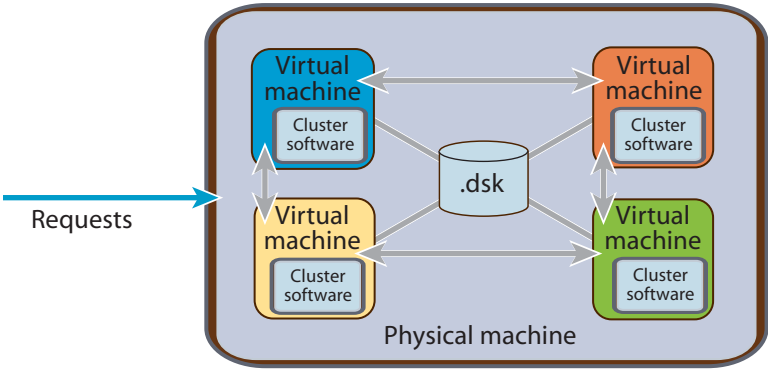
Network Load Balancing, Microsoft Clustering Service and Veritas Clustering Service run without modification in virtual machines on ESX Server 2.1.

Use of clustering services in virtual machines provides high availability with less hardware (such as machines and network adapters).

Clustering Scenarios

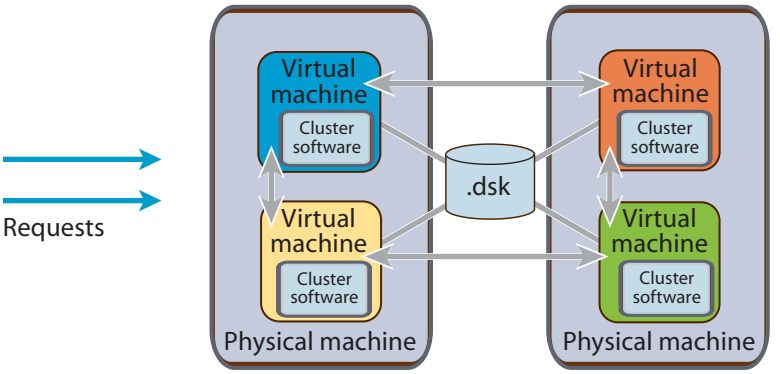
Several scenarios are possible for clustering in virtual machines.

Cluster in a Box — This provides simple clustering to deal with software crashes or administrative errors. The cluster consists of multiple virtual machines on a single physical machine. It supports shared disks without any shared SCSI hardware. It supports heartbeat network without any extra network adapters.



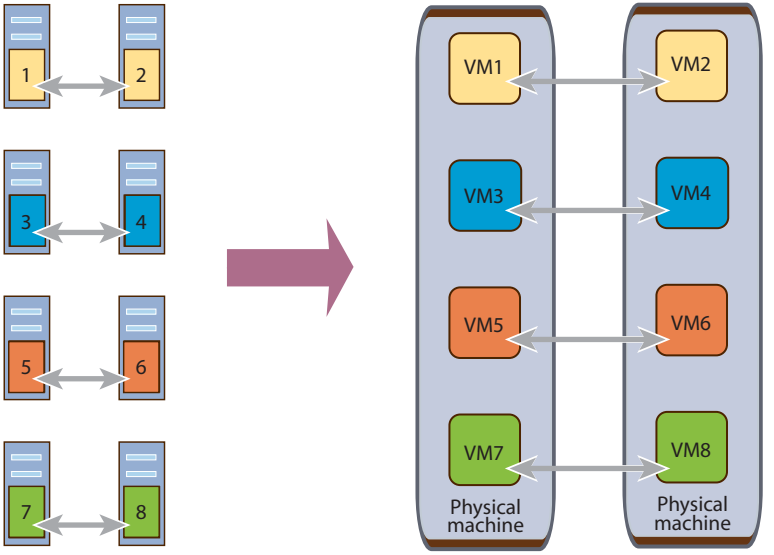
A four-node cluster on a single physical machine; each node is running clustering software

Cluster across Boxes — This type of cluster also consists of virtual machines. The virtual disks are stored on real shared disks, so all virtual machines can access them. Using this type of cluster, you can deal with the crash of a physical machine.



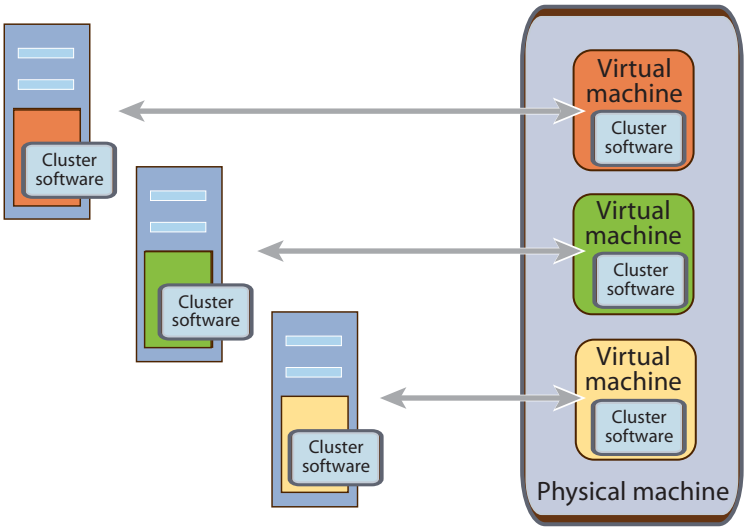
A four-node cluster using two physical machines; each node is running clustering software.

Consolidating Clusters — This type of cluster combines features of the previous two types. For example, you can consolidate four clusters of two machines each to two physical machines with four virtual machines each. This provides protection from both hardware and software failures.



Four two-node clusters moved from eight physical machines to two.

Cost-effective Standby Host — Provide a standby host for multiple physical machines on one standby box with multiple virtual machines.



A standby host using three virtual machines on a single physical machine; all are running clustering software.

Configuring Virtual Machine Clusters with Shared Disks

To create a set of clustered virtual machines, you need to configure each of them with the following:

- A primary virtual SCSI host adapter with one SCSI virtual disk
- At least two virtual network adapters
  - A public network adapter connected to `vmnicx` (that is, to `vmnic0` or higher). A vmnic is a virtual machine device that uses a network adapter dedicated to the virtual machines.
  - A private network adapter connected to `vmnicx` (that is, to `vmnic0` or higher) or to `vmnet_x` (that is, to `vmnet_0` or higher). This device selection must match in all virtual machines in a cluster set. This is the network adapter that the clustering service will use to monitor the heartbeat between nodes.
- The remaining default virtual machine devices (such as the CD-ROM drive and the floppy disk drive).

In addition to the above devices, the following is required for shared storage:

- A secondary virtual SCSI host adapter

- One or more virtual disks that will be shared attached to the secondary SCSI host adapter

Important Notes

- Each virtual machine by default has five PCI slots available. In this configuration (two network adapters and two SCSI host bus adapters), four of these slots are used. This leaves one more PCI slot for a third network adapter if needed.
- VMware virtual machines currently emulate only the SCSI-2 disk reservation protocol and do not support applications using SCSI-3 disk reservations. However, all popular clustering software (including MSCS and VCS) currently uses SCSI-2 reservations.

Two Node Cluster with Microsoft Cluster Service on a Single ESX Server Machine

This procedure creates a two-node cluster using Microsoft Cluster Service on a single ESX Server machine and uses the following:

- Portsaid = host name of node 1 of the cluster
- Kena = host name of node 2 of the cluster
- Arish = public host name of the cluster
- sharedfs = VMFS volume label of the shared storage
- vms = VMFS volume label of the local storage

Note: Virtual disks stored on vms and sharedfs can also be stored on the same partition. In this case, use the partition label on which these virtual disks reside.

Creating the First Node's Base Virtual Machine

1. Access the VMware Management Interface at `https://<hostname>/` and log on as the user who will own the virtual machine.
2. Click **Add Virtual Machine**.
3. Keep the default **Guest Operating System** selection of **Microsoft Windows 2000 Server.**

   Note: This example uses Microsoft Windows 2000 Server as the guest operating system. You may substitute another Windows operating system that supports Microsoft Cluster Service.
4. Change the **Display Name** field to describe the virtual machine — for example, `MSCS Node 1 (Portsaid)`.

5. Change the **Location** of the virtual machine configuration file to `/home/<user>/vmware/cluster1/cluster1.vmx`.
6. Click `Next`.
7. Select the number of processors you want the guest operating system to use, up to 2.
8. Change **Memory** to show the amount of RAM you want to allocate to this virtual machine.
9. Click **Next**.
10. Click **Blank** to create a new virtual disk.
11. Choose the VMFS volume on which you want to store the virtual disk.
12. Give the virtual disk image a unique name — for example, `cluster1.dsk`.
13. If you need a primary SCSI disk larger than 4GB, enter the appropriate value in the **Capacity** field.
14. Choose the virtual SCSI node to which you want to attach the virtual disk.
15. By default, the disk mode is set to persistent. Click **Persistent** to verify the disk mode.
16. Click **Next**.

You have successfully created the virtual machine.

The hardware tab for this virtual machine appears. From that tab, you now need to add additional hardware devices.

Virtual Disk Configuration — You need a shared SCSI controller and shared SCSI disks for shared access to clustered services and data.

To add a shared SCSI controller and shared SCSI disks, click the **Hardware** tab, then take the following steps:

1. Click **Add Device**.
2. Click **Hard disk**.
3. Click **Blank** to create a new virtual disk.
4. Choose the VMFS volume on which you want to store the virtual disk.
5. Give the virtual disk image a unique name — for example, `quorum.dsk`.
6. Enter the appropriate value in the **Capacity** field.
7. Choose the virtual SCSI node to which you want to attach the virtual disk.

Note: Shared disks must be attached to a separate SCSI controller. Select SCSI 1:1

8. By default, the disk mode is set to persistent. Click **Persistent** to verify the disk mode.
9. Click **OK**.

   Note: A new virtual disk and SCSI Controller 1 are now visible on the hardware tab.
10. Click **Edit** next to **SCSI Controller 1** and change the bus sharing from **none** to **virtual**.

    From the **Bus Sharing** drop-down list, select **virtual**, then Click **OK**.

Repeat step 1–step 9 to create an additional shared virtual disk using SCSI 1:2 with the filename `shared2.dsk`.

Network Device Configuration — You need an additional virtual network adapter to be used by Microsoft Cluster Service to maintain the cluster heartbeat. To add this adapter, click the **Hardware** tab for this virtual machine, then take the following steps:

1. Click **Add Device**.
2. Click **Network Adapter**.
3. From the **Device Binding** drop-down list choose **vmnet_0**. This attaches the second Ethernet adapter to a private network between the cluster nodes.
4. Click **OK**.

You have created the first cluster node virtual machine.

Installing the Guest Operating System

Now you need to install Windows 2000 Advanced Server in the virtual machine you just created

1. Insert the Windows 2000 Advanced Server CD in the ESX Server machine's CD-ROM drive.
2. In the management interface, click the blue terminal icon next to the virtual machine's name to launch the remote console.
3. Log on as the user who created the virtual machine or as root.
4. Click **Power On**.
5. Install Windows 2000 Advanced Server on the disk connected to scsi0.

6. Accept all the default options during the installation. Do not install the clustering service at this time.
7. When the installation is completed, install VMware Tools in the guest operating system.

Cloning the Virtual Machine

Now that you have a virtual machine with Windows 2000 Advanced Server installed, you can save time by cloning this virtual machine as follows:

1. Run `sysprep.exe`, which is available on the Windows 2000 CD in the `\support\tools\deploy.cab` file. This strips the security ID assigned to the guest operating system and resets the machine information as well as the TCP/IP network configuration.
2. Shut down the guest operating system and power off the virtual machine.
3. Remove the Windows 2000 Advanced Server CD from the server's CD-ROM drive.
4. On the management interface's Overview page, click **Manage Files.**
5. Drill down to the `vmfs` folder, then the `vms` folder. This may take some time to refresh.
6. Select the check box next to the `cluster1.dsk` file.
7. Click **Copy**.
8. Click **Paste**.
9. When the copy process is complete, select the check box next to the file `copy of cluster1.dsk`.
10. Click the **Edit Properties** button.
11. Change the filename to `cluster2.dsk`.
12. Click **OK**.
13. Close the Manage Files window.

This concludes the cloning process. Now continue with creating the second node virtual machine

Creating the Second Node Virtual Machine

Create a new virtual machine as follows:

1. On the management interface's Overview page, click **Add Virtual Machine**.
2. Keep the default **Guest Operating System** selection of **Microsoft Windows 2000 Server**.
3. Change the **Display Name** field to describe the virtual machine — for example, `SCS Node 2 (Kena)`.
4. Change the **Location** to `home/<user>/vmware/cluster2/cluster2.vmx`
5. Click **Next**.
6. Select the number of processors you want the guest operating system to use, up to 2.
7. Change **Memory** to show the amount of RAM you want to allocate to this virtual machine.
8. Click **Next**.
9. Click **Existing** to attach an existing virtual disk to this virtual machine.
10. From the **Virtual Disk Image** drop-down list, choose `cluster2.dsk`.
11. Choose the virtual SCSI node to which you want to attach the virtual disk.
12. Click **Next**.

Virtual Disk Configuration — You need a shared SCSI controller and shared SCSI disks for shared access to clustered services and data.

To add a shared SCSI controller and shared SCSI disks, click the **Hardware** tab for this virtual machine, then take the following steps:

1. Click **Add Device**.
2. 2.Click **Hard Disk**.
3. Click **Blank** to create a new virtual disk.
4. 4.Choose the **VMFS Volume** on which you want to store the virtual disk.
5. Give the virtual disk image a unique name — for example, `quorum.dsk`.
6. Enter the appropriate value in the **Capacity** field.
7. Choose the virtual SCSI node to which you want to attach the virtual disk.

   Note: Shared disks must be attached to a separate SCSI controller. Select SCSI 1:1.

8. By default the disk mode is set to persistent. Click **Persistent** to verify the disk mode.
9. Click **OK**.

   Note: A new virtual disk and SCSI Controller 1 are now visible on the hardware tab.
10. Click **Edit** next to **SCSI Controller 1** to change the bus sharing from **none** to **virtual**.
11. From the **Bus Sharing** drop-down list select **virtual**, then click **OK**.

Repeat step 1–step 9 create an additional shared virtual disk using SCSI 1:2 with the filename `shared2.dsk`.

Network Device Configuration — You need an additional virtual network adapter to be used by Microsoft Cluster Service to maintain the cluster heartbeat. To add this adapter, click the **Hardware** tab for this virtual machine, then take the following steps:

1. Click **Add Device**.
2. Click **Network Adapter**.
3. From the **Device Binding** drop-down list choose **vmnet_0**. This attaches the second Ethernet adapter to a private network between the cluster nodes.
4. Click **OK**.

You have created the second cluster node virtual machine.

Go to the management interface's Overview page. The management interface should list both virtual machines and show them powered off.

Installing Microsoft Cluster Service

1. Start the node 1 virtual machine.
2. Follow the Windows 2000 Advanced Server mini-setup prompts to enter Advanced Server's serial number, the host name (Portsaid) and the IP addresses. Note that you need to enter the addresses for both public and private network adapters.

   For the public network adapter, enter an IP address that belongs to the physical network.

   For the private IP address, you may use an address like 192.168.x.x with a class C subnet mask (255.255.255.0).
3. At the end of the process, Windows automatically reboots.

4. Start the Disk Administrator and change both shared disks to basic disks.
5. Format both shared virtual disks with NTFS if they are not already formatted.
6. Assign the first shared disk to Q: (quorum) and the second disk to R:.

   If you have joined this virtual machine to an existing Active Directory domain, skip to step 11.
7. Run `dcpromo.exe` from the command prompt. This starts the Active Directory Wizard.
8. Set up the current machine as a domain controller. For the domain name, use something like `vmcluster.domain.com` where `domain.com` is your DNS domain and `vmcluster` is your Active Directory domain. This node may be setup as a new domain tree and also a new domain forest, or it may join existing ones.
9. Make sure the DNS server is installed.
10. Set the domain permissions as mixed mode unless you plan otherwise.
11. To add a cluster services account in the domain, go to Programs > Administrative Tools > Active Directory Users and Computers.
12. Add an account named `cluster`, check **User cannot change password** and **Password never expires**.
13. Insert the Windows 2000 Advanced Server CD in the server's CD-ROM drive.
14. Go to **Control Panel** > **Add/Remove Programs**.
15. Select **Add/Remove Windows Components**.
16. Check the **Cluster Service** component.
17. Click **Next**. Follow the prompts to install the service.
18. As you configure Cluster Service, choose **Form a New Cluster**.
19. Specify the cluster name (Arish)
20. Specify the cluster IP address. This is the address that will represent the cluster. It must be on the same network as that of the vmnic0.
21. Specify the cluster service account created above.
22. Specify that both shared disks should be managed by the cluster service.
23. Indicate the shared disk (Q:) to be the quorum disk.
24. Specify which network adapter is public and which is private.

25. Stop the cluster service on the local node (from Cluster Manager, right-click the node name), so the second virtual machine can access the shared disks.
26. Start the node 2 virtual machine.
27. Repeat step 2 and step 3 above.
28. Start the Disk Administrator and assign the first shared disk to Q: (quorum) and the second disk to R:.
29. Start `dcpromo.exe` and add this virtual machine as a domain controller in the same domain created in step 8 above or add it to an existing domain. You must match the setup done in step 8.
30. In the node 1 virtual machine, start the cluster service by reversing step 25 above.
31. In the node 2 virtual machine, repeat step 14–step 24 above with one exception: In step 18, select Join a Cluster.

This concludes the Microsoft Cluster Service installation and configuration.

Running Microsoft Cluster Service

Microsoft Cluster Service should operate normally in the virtual machine once it is installed.

Note: Some disk errors are recorded in the Windows event log in normal operation. These error messages have a format similar to

```
The driver detected a controller error on
\Device\Scsi\BusLogic3
```

They should be reported periodically only on the passive node of the cluster and should also be reported when the passive node is taking over during a failover. The errors are reported because the active node of the cluster has reserved the shared virtual disk(s). The passive node periodically probes the shared disk and receives a SCSI reservation conflict error. This is normal operation.

Two Nodes with Microsoft Cluster Service on Separate ESX Server Machines

This procedure creates a two node cluster in virtual machines that will run on two separate ESX Server machines. It uses the same naming conventions as in the previous procedure.

In addition, the physical shared storage is either:

- Shared SCSI
- A storage area network (SAN)

For this exercise the VMFS partition for the internal storage on each ESX Server computer is labeled vms. The VMFS partition for the shared storage is labeled sharedfs.

- The VMFS partition for the internal storage on each ESX Server machine is labeled vms.
- The VMFS partition for the shared storage is labeled sharedfs.

Each ESX Server machine must have an additional physical network adapter assigned to the virtual machines to use for the private network that monitors the heartbeat. The procedure assumes this network adapter uses the device named vmnic1. You should connect the private network adapter to a separate network from that used by the public network adapter.

Creating the First Node's Base Virtual Machine

Follow the procedure in Creating the First Node's Base Virtual Machine on page 335, with the following changes:

- In the Virtual Disk Configuration section, in step 10 click **Edit** next to **SCSI Controller 1** to change the bus sharing from **none** to **physical** instead of virtual. From the **Bus Sharing** drop-down list select **physical**, then click **OK**.
- In the Network Device Configuration section, in step 3 use vmnic1 instead of vmnet_0 as the device used by Ethernet Adapter 1.
- Access the virtual machine menu by clicking the arrow to the right of the virtual machine icon. Choose **Configure Options**. Under Verbose Options, click the **click here** link.

  Change the specifications of `scsi1:1.name` and `scsi1:2.name` to use the strict `vmhba` name (for example, `vmhba0:1:0:1:shared1.dsk`) for the VMFS partition, rather than the VMFS name (for example, `sharedfs:shared1.dsk`). The reason for this change is that if one ESX Server machine reboots while a virtual machine on the other physical machine is reserving the shared SCSI disk, ESX Server cannot read the VMFS name on the shared disk when it is loaded and initialized. If the shared virtual disk is not specified using the full vmhba name, ESX Server cannot determine the disk specified by the VMFS name and gives an error when restarting the virtual machine.

  When you have made these changes, click **OK**.

In addition to these minor changes, you need to change the access rights of the VMFS partition where you store the shared virtual disks. By default VMFS partitions are

configured for public access. In order to support clustering, the VMFS partition needs to be configured for shared access.

Take the following steps to change the access settings for the VMFS partition:

1. From the management interface click the **Options** tab
2. Click **Storage Configuration**.
3. Identify the disk volume that contains the VMFS partition where the shared virtual disks are stored. Click **Edit** for the disk volume.
4. From the **VMFS Access** drop-down list, choose **Shared**.
5. Click **OK**.

You have created the first cluster node virtual machine.

Installing the Guest Operating System

Follow the procedure in Installing the Guest Operating System on page 337.

Cloning the Virtual Machine

Now that you have a virtual machine with Windows 2000 Advanced Server installed, you can save time by cloning this virtual machine as follows:

1. Run `sysprep.exe`, which is available on the Windows 2000 CD in the `\support\tools\deploy.cab` file. This strips the Security ID assigned to the guest operating system and resets the machine information as well as the TCP/IP network configuration.
2. Shut down the guest operating system and power off the virtual machine.
3. Go to the console of the second ESX Server machine. This is where you will copy the virtual disk that resulted from creating the first node.
4. Log on as root.
5. Change directories: `cd /vmfs/vms`

   This assumes that the internal storage for the second server is in a VMFS partition labeled vms.
6. Use the `ftp` command: `ftp <server1-hostname>`
7. Change directories: `cd /vmfs/vms`

   This changes the current directory to the VMFS partition on the first server where you created the first node's virtual disk.
8. Set the type to binary: `bin`

This sets the transfer mode to binary. If you use text transfer mode, the virtual disk may not be usable on the target server.

9. Type: `hash on`

   This turns on the display of a series of hash signs as a transfer progress indicator.

10. Retrieve the virtual disk file: `get cluster1.dsk`

    This initiates the transfer of the virtual disk file to the current directory on the second ESX Server machine.

11. Quit the ftp session: `bye`

    After the file transfer is completed, type the `bye` command to end the FTP session.

12. Rename the file: `mv cluster1.dsk cluster2.dsk`

    This renames the virtual disk to `cluster2.dsk`.

This concludes the cloning process. Continue with creating the second node virtual machine.

Creating the Second Node Virtual Machine

Follow the procedure in Creating the First Node's Base Virtual Machine on page 335, noting the following differences:

- In the Virtual Disk Configuration section, step 10, click **Edit** next to **SCSI Controller 1** to change the bus sharing from **none** to **physical** instead of virtual. From the **Bus Sharing** drop-down list, choose **physical**, then click **OK**.
- In the Network Device Configuration section, step 3, from the **Device Binding** drop-down list, choose vmnic1 instead of vmnet_0. This attaches the second Ethernet adapter to the second physical adapter designated for virtual machine use. This is used to create a private network between the cluster nodes.
- Change the specifications of `scsi1:1.name` and `scsi1:2.name` as you did when creating the first node's base virtual machine.

Clustering Using a Raw SCSI Disk

The shared disk used for clustering can also be a complete shared SCSI disk, rather than a VMFS file on a shared disk. Using a raw SCSI disk as a shared disk may simplify initial setup. It may be especially useful for importing an existing physical cluster that already has cluster data on a SCSI disk. In addition, using a raw SCSI disk as a shared disk allows a virtual machine to participate in a cluster with a physical machine. For example, the virtual machine can be used as the passive node for a physical machine that is the active node.

In order for the virtual machine to access a physical disk, the instructions in the Virtual Disk Configuration section on page 339 should be replaced with the following steps:

To add a physical SCSI controller and shared raw SCSI disks, go to the **Hardware** tab and take the following steps:

1. Click **Add Device**.
2. Click **Hard disk**.
3. Click **System LUN/Disk** to give your virtual machine direct access to a SAN or shared storage volume.
4. Choose the **LUN/Partition** you want to attach to this VM as a raw disk.

   Note: In ESX Server, physical disks are identified by a vmhba number. For example, vmhba0:1:2:1 means physical adapter vmhba0, target 1, LUN 2, partition 1. When the final number is :0, that indicates you are specifying the entire disk, rather than a particular partition.
5. Choose the virtual SCSI node to which you want to attach the raw disk.

   Note: Shared disks must be attached to a separate SCSI controller from the system disk. Select, SCSI 1:1
6. Click **OK**.

   A new virtual disk and SCSI Controller 1 appear on the Hardware tab.
7. Click **Edit** next to **SCSI Controller 1** to change the bus sharing from **none** to **physical**.
8. From the **Bus Sharing** drop-down list choose **physical**, then click **OK**.

   Setting the bus sharing to physical makes sure that all the SCSI reserve and reset commands go through to the physical disk.

Repeat step 1–step 8 to create an additional shared raw disk using SCSI 1:2.

You have completed the virtual machine configuration.

Installing Microsoft Cluster Service

Follow the procedure in Installing Microsoft Cluster Service on page 340.

Additional Notes for Clustering Across Physical Machines

- For maximum flexibility, put each shared virtual disk on a separate VMFS on a separate SCSI disk (or LUN). The reason for this is that SCSI reservation can be done only at the granularity of a complete SCSI disk or LUN. If two shared virtual disks are on the same VMFS, reserving one disk will also reserve the other disk. If you choose to put more than one shared disk on the same VMFS (as in the

example installation above), always put these virtual disks in the same MSCS resource group. That ensures the disks are always reserved by the same computer and are always failed over at the same time.

- Ensure that the swap file for each ESX Server machine is not on any of the physical shared disks. Since the shared disks are reserved by one host or another, the swap file may become inaccessible to one host or the other during the operation of the cluster.
- If you are accessing the shared disks on a storage network (SAN) using a QLogic host bus adapter, you must use particular values for some QLogic configuration settings. Reboot your physical machine and enter the QLogic configuration utility during bootup. Under **Advanced Configuration Settings**, ensure that
  - **Enable Target Reset** is set to **Yes**.
  - **Full LIP Login** is set to **Yes**.
  - **Full LIP Reset** is set to **No**.
- If you are accessing the shared disks on a SAN using an Emulex host bus adapter, you need to take the following extra steps:
  a. On the Options > Advanced Settings page, Set **DiskUseDeviceReset** to 1.
  b. Supply an extra parameter to the Emulex driver when it is loaded. You do this by editing the file `/etc/vmware/hwconfig`. First, identify the bus, slot and function holding the first (or only) Emulex card. You can find this information by looking at the Startup Profile page. Then add a line with the format

     ```
     device.vmnix.6.14.0.options = "lpfc_delay_rsp_err=0"
     ```

     to the end of `/etc/vmware/hwconfig`. Here, the numbers `6.14.0` specify the bus, slot and function where the Emulex card is located. If you have more than one Emulex card, you should have only a line referencing the first card.
- If you are doing multipathing and can access your shared cluster disk via multiple HBAs from a host, then you need to modify another configuration file. Go to the Options > Advanced Settings page and set **DiskResetOnFailover** to 1. If an HBA failover occurs on the host, this option causes a SCSI bus reset to be issued after the failover happens. This bus reset allows the second HBA to access a shared disk, even if the disk has been reserved by the first HBA. The clustering software then automatically reserves the disk again via the second HBA.

Running Microsoft Cluster Service

Microsoft Cluster Service should operate normally in the virtual machines once it is installed.

Note: Some disk errors are recorded in the Windows event log in normal operation. These error messages have a format similar to

```
The driver detected a controller error on
\Device\Scsi\BusLogic3
```

They should be reported periodically only on the passive node of the cluster and should also be reported when the passive node is taking over during a failover. The errors are reported because the active node of the cluster has reserved the shared virtual disk. The passive node periodically probes the shared disk and receives a SCSI reservation conflict error.

VMFS Locking and SCSI Reservation

For a shared SCSI disk that can be accessed by multiple ESX Server machines, two kinds of locking may be in use. These two kinds of locking are somewhat independent and can cause confusion. The shared SCSI disk may be on shared SCSI bus or, more likely, on a storage area network (SAN).

VMFS File System Locking

The first kind of locking is VMFS file system locking. ESX Server locks VMFS file systems on a server level when a VMFS file system is configured as a public or shared file system. This locking is done in order to ensure that there is no corruption caused by multiple accesses to the file system by different hosts.

If a VMFS-1 volume is configured in public mode, only one server can ever access that VMFS at a time. If one server is accessing the VMFS-1 volume, through a virtual machine or a file system command, then a file system operation by another host fails. For example, a `vmkfstools` command fails with a message that says:

```
vmkfstools: file system is locked by another server. Use
'vmkfstools --recover' to unlock file system if no other
server is accessing
```

Typically, you should not run `vmkfstools --recover` at this point, since another host is actually using the file system. The error message simply indicates that this server cannot access the VMFS until the other server has finished accessing it. However, if a server fails while accessing the file system, the file system may stay in the locked state and you may need to run `vmkfstools --recover`.

In a public VMFS-2 volume, locking is at a per-file level, resulting in fewer locking issues. However, you may still encounter the preceding message and may need to use `vmkfstools --recover`, if a server fails.

If a VMFS is used to store a virtual disk that is accessed by multiple virtual machines on multiple physical servers for the purposes of failover clustering, the VMFS should be configured as a shared file system. Then, the locking protocol is slightly relaxed to allow multiple virtual machines on different servers to access the same VMFS file at the same time. However, file system commands do the same locking as with public file systems (that is, per-VMFS in VMFS-1 volumes and per-file in VMFS-2 volumes).

Additionally, when multiple virtual machines access the VMFS, the VMFS file system enters a read-only mode in which it is impossible to create, delete or change the size of files. However, the contents of the individual files can still be modified. If you later want to create or remove VMFS files, you must stop all virtual machines using the VMFS and re-enter writable mode by using this command:

```
vmkfstools --config writable vmhba0:1:0:0
```

Substitute the name of the appropriate disk or VMFS in place of `vmhba0:1:0:0`.

Locking at SCSI Disk Level

The second kind of locking is locking at the SCSI disk level, which is called SCSI disk reservation.

Any server connected to a SCSI disk can issue a SCSI command to reserve the disk. If no other server is already reserving the disk, the current server obtains a reservation on the disk. As long as that reservation exists, no other server can access the disk. All SCSI commands to that disk by other servers fail with an appropriate error code.

If a `vmkfstools` command is attempted on a VMFS on a disk that is reserved by another server, the `vmkfstools` command fails with a message that says:

```
vmkfstools: shared SCSI disk is reserved by another
server. Use 'vmkfstools -L release/reset' to end
reservation if no other server is using the SCSI
reservation
```

Similarly, a virtual machine fails to start if its virtual boot disk is stored on a physical disk that is reserved by another host.

Most applications do not ever reserve a SCSI disk. However, failover clustering software reserves SCSI disks in order to ensure that only the active node is able to access the shared SCSI disk. Therefore, you should expect that the shared disk in a physical clustering setup is reserved when the cluster is active. Similarly, for a virtual

machine cluster that is running across physical machines, reservations by the clustering software are transmitted through to the physical shared disk.

If you encounter a disk that is reserved unexpectedly, you should try to determine if some clustering software has explicitly reserved the disk. If not, you can release the reservation on the server that has the reservation by running a command in this format:

```
vmkfstools -L release vmhba0:1:0:0
```

Substitute the name of the appropriate disk or VMFS in place of `vmhba0:1:0:0`. If you cannot determine which server holds the reservation, you may be able to eliminate the reservation by issuing a SCSI bus reset on any server machine using a command in this format:

```
vmkfstools -L reset vmhba0:1:0:0
```

Using LUN Masking to Avoid Locking Issues

Locking issues are especially likely to happen on a SAN, where multiple users may be accessing some of the same disks or may mistakenly access a disk assigned to another user.

It is often helpful to use LUN masking or zoning to limit what disks are visible to each server in the system, and therefore reduce the ways in which one user can affect another user. In particular, the use of LUN masking or zoning can help prevent problems such as those described above in which one server unexpectedly locks or reserves the wrong SCSI disk.

Network Load Balancing

What Is Network Load Balancing?

Network Load Balancing is a Windows 2000 Advanced Server feature. By using Network Load Balancing to build a server cluster, you can enhance the availability of Internet server programs, such as those used on Web, proxy, domain name service (DNS), FTP, virtual private network (VPN) and streaming media servers. Network Load Balancing can help you scale your server's performance.

NLB can be used in unicast or multicast modes. If the cluster is operating in unicast mode (the default), ordinary network communication among cluster hosts is not possible unless each cluster host has at least two network adapters.

Creating Multinode Network Load Balancing Clusters on ESX Server

This section covers procedures for creating a Network Load Balancing cluster using nodes running in virtual machines. These virtual machines can be located on one or more ESX Server machines.

Creating the First Node's Base Virtual Machine

1. Access the VMware Management Interface at `https://<hostname>/` and log on as the user who will own the virtual machine.
2. Click **Add Virtual Machine**.
3. Keep the default **Guest Operating System** selection of **Microsoft Windows 2000 Server**.

   Note: This example uses Microsoft Windows 2000 Server as the guest operating system. You may substitute another Windows operating system that supports Microsoft Cluster Service.
4. Change the **Display Name** field to describe the virtual machine — for example, `MSCS Node 1 (Portsaid)`.
5. Change the **Location** of the virtual machine configuration file to `/home/<user>/vmware/cluster1/cluster1.vmx`.
6. Click **Next**.
7. Choose the number of processors you want the guest operating system to use, up to 2.

8. Change **Memory** to show the amount of RAM you want to allocate to this virtual machine.
9. Click **Next**.
10. Click **Blank** to create a new virtual disk.
11. Choose the VMFS volume on which you want to store the virtual disk.
12. Give the virtual disk file a unique name — for example, `cluster1.dsk`.
13. If you need a primary SCSI disk larger than 4GB, enter the appropriate value in the **Capacity** field.
14. Choose the virtual SCSI node to which you want to attach the virtual disk.
15. By default, the disk mode is set to persistent. Click **Persistent** to verify the disk mode.
16. Click **Next**.

You have created the virtual machine.

The hardware tab for this virtual machine appears. Use it to add hardware devices.

Network Device Configuration — You must add another virtual network adapter the cluster nodes will use to communicate with each other.

1. On the hardware tab for this virtual machine, click **Add Device**.
2. Click **Network Adapter**.
3. From the **Device Binding** drop-down list, choose **vmnic1**.

   Note: If all nodes of the cluster will reside on the same ESX Server machine, you may use vmnet_0 for the second network adapter. This allows all nodes to communicate with each other on a private virtual network connected to the vmnet_0 virtual switch.
4. Click **OK**.

You have finished creating and configuring the first node virtual machine.

Installing the Guest Operating System

Now you need to install Windows 2000 Advanced Server in the virtual machine.

1. Insert the Windows 2000 Advanced Server CD in the ESX Server machine's CD-ROM drive.
2. In the management interface, click the blue terminal icon next to the virtual machine's name to launch the remote console.
3. Log on using the user account that created the virtual machine or as root.

4. Click **Power On**.
5. Install Windows 2000 Advanced Server on the disk connected to scsi0.
6. Accept all the default options during the installation. You may opt to install the applications at this time. Network Load Balancing is installed by default.
7. When the installation is completed, install VMware Tools in the guest operating system.
8. Remove the Windows 2000 Advanced Server CD from the server's CD-ROM drive.

Cloning the Virtual Machine

Now that you have a virtual machine with Windows 2000 Advanced Server installed, you can save time by cloning this virtual machine as follows:

1. Run `sysprep.exe`, which is available on the Windows 2000 CD in the `\support\tools\deploy.cab` file. This strips the security ID assigned to the guest operating system and resets the machine information as well as the TCP/IP network configuration.
2. Shut down the guest operating system and power off the virtual machine.
3. On the management interface's Overview page, click **Manage Files.**
4. Drill down to the `vmfs` folder then the `vms` folder. This may take some time to refresh.
5. Select the check box next to the `cluster1.dsk` file.
6. Click **Copy**.
7. Click **Paste**.
8. When the copy process is complete, select the check box next to the file `copy of cluster1.dsk`.
9. Click **Edit Properties**.
10. Change the filename to `cluster2.dsk`.
11. Click **OK**.
12. Close the Manage Files window.

This concludes the cloning process. Now continue with creating the second node virtual machine

Cloning the Virtual Machine, an Alternate Method

1. Run `sysprep.exe`, which is available on the Windows 2000 CD in the `\support\tools\deploy.cab` file. This strips the security ID assigned to the guest operating system and resets the machine information as well as the TCP/IP network configuration.
2. Shut down the guest operating system and power off the virtual machine.
3. At the ESX Server console, log on as root.
4. Change directories: `cd /vmfs/vms`

   This changes the current directory to the VMFS partition where you created the virtual disk.
5. Create a copy of the virtual disk: `cp cluster1.dsk cluster2.dsk`

   This creates a copy of the virtual disk. You may repeat this command using a different target filename if you want to create more than one copy.

This concludes the cloning process. Now continue with creating the second node virtual machine

Cloning the Virtual Machine to Another ESX Server Machine

This section assumes that you are planning to run each node of an eight-node cluster on a separate ESX Server machine. If you are planning to run a different number of nodes on each ESX Server machine, adjust the procedure accordingly.

1. Run `sysprep.exe`, which is available on the Windows 2000 CD in the `\support\tools\deploy.cab` file. This strips the security ID assigned to the guest operating system and resets the machine information as well as the TCP/IP network configuration.
2. Shut down the guest operating system and power off the virtual machine.
3. At the ESX Server console (on a machine other than the one where you created the first node), log on as root.
4. Change directories: `cd /vmfs/vms`

   This changes the current directory to the VMFS partition where you want to create the virtual disk.
5. Use the `ftp` command: `ftp <first-ESX-Server-Hostname>`
6. Change directories: `cd /vmfs/vms`
7. Set the type to binary: `bin`
8. Type: `hash on`

9. Retrieve the virtual disk file: `get cluster1.dsk`

   This transfers a copy of the virtual disk to the second ESX Server machine's VMFS partition.

10. Quit the `ftp` session: `bye`

11. Rename the virtual disk file: `mv cluster1.dsk cluster9.dsk`

    This renames the virtual disk file to `cluster9.dsk`. This assumes that this ESX Server machine will host nodes 9 and up.

    Repeat this command using a different target file name if you want to create more than one copy.

This concludes the cloning process. Now continue with creating the second node virtual machine

Repeat step 3–step 11 on each ESX Server machine that will participate in the cluster.

Creating the Second Node Virtual Machine

Create a new virtual machine as follows:

1. On the management interface's Overview page, click **Add Virtual Machine**.
2. Keep the default **Guest Operating System** selection of **Microsoft Windows 2000 Server**.
3. Change the **Display Name** field to describe the virtual machine — for example, `MSCS Node 2 (Kena)`.
4. Change the **Location** of the virtual machine to `/home/<user>/vmware./cluster2/cluster2.vmx`.
5. Click **Next**.
6. Choose the number of processors you want the guest operating system to utilize, up to 2.
7. Change **Memory** to show the amount of RAM you want to allocate to this virtual machine.
8. Click **Next**.
9. Click **Existing** to attach an existing virtual disk to this virtual machine.
10. From the **Virtual Disk Image** drop-down list, choose **cluster2.dsk**.
11. Choose the virtual SCSI node to which you want to attach the virtual disk.
12. Click **Next**.

Network Device Configuration — You need to add another network adapter that the cluster nodes will use to communicate with each other.

1. On the hardware tab for this virtual machine, click **Add Device**.
2. Click **Network Adapter**.
3. From the **Device Binding** drop-down list, choose **vmnic1**.

   Note: If all nodes of the cluster will reside on the same ESX Server machine, you may use vmnet_0 for the second network adapter. This allows all nodes to communicate with each other on a private virtual network connected to the vmnet_0 virtual switch.
4. Click **OK**.

You have finished creating and configuring the new node's virtual machine.

Go to the management interface's Overview page. Both virtual machines should be listed and shown as powered off.

You may repeat this procedure at each ESX Server machine on which you created copies of the virtual disk.

Configuring the Network Load Balancing Cluster

You can cluster up to 32 nodes using Network Load Balancing To configure the cluster, follow this procedure for each node that will join the cluster.

1. Using the management interface connected to the first ESX Server machine, launch the remote console for the first node.
2. Power on the virtual machine.
3. Follow the Windows 2000 Server mini-setup prompts to enter the Windows 2000 Advanced Server serial number and the host name and IP addresses.
4. At the end of the process, Windows automatically reboots.
5. Log on to the Windows 2000 Advanced Server virtual machine as Administrator.
6. Open Network and Dial-up Connections.
7. Right-click the local area connection on which you will install Network Load Balancing and choose **Properties**. The Local Area Connection Properties dialog box appears.
8. Under **Components checked are used by this connection**, select the **Network Load Balancing** check box.
9. Click **Properties**.

10. On the **Cluster Parameters** tab, configure cluster operations using these parameters:
    - **Primary IP Address**: This is the address for the cluster as a whole. This is the address that the clients will use to access the cluster.
    - **Subnet Mask**: This is the subnet mask of the network to which the above address belongs.
    - **Multicast**: Leave this unchecked, unless your virtual machine was configured with a single network adapter.

      Note that all members of the cluster must use the same setting for this option.
    - Refer to Network Load Balancing Help for the remaining options.
11. After you have finished, click **OK**. You return to the Local Area Connection Properties dialog box.
12. Click **OK** again to return to the Local Area Connection Status dialog box.
13. Right-click the local area connection on which Network Load Balancing is to be installed, and click **Properties.**
14. Select **Internet Protocol (TCP/IP)**, then click **Properties.**
15. Set up TCP/IP for Network Load Balancing. For more information and links to procedures for setting up TCP/IP for Network Load Balancing on single and multiple network adapters, see Related Topics in the Network Load Balancing Help.

    Note: You must add Cluster's Primary IP Address to the list of IP Addresses bound to the adapter.
16. Repeat these steps on each host to be used in your Network Load Balancing cluster.

Guidelines for Specific Configurations

Configuring FAStT Storage for Failover and Multipath Visibility

Use the following guidelines to configure a FAStT Storage Processor and QLogic controller so you can use HBA failover along with multipath SAN visibility and Microsoft Cluster Services.

Be sure your FAStT is running firmware version 8.21. The firmware update is available on the IBM Web site at http://www.pc.ibm.com/qtechinfo/MIGR-43752.html.

Be sure your FAStT has RST propagation and unassigned LUN claiming enabled. You can enable these options by running a script developed by IBM. To do so, you should be at the computer where you run IBM FAStT Storage Manager. Take these steps:

1. Copy the following lines and save them in a text file named `LinuxCluster.scr`. Be sure you do not get extra line breaks in the file. They may prevent the script from running correctly.

```
// Show Host Topology will show what Het Hosts
// are set for what OS
//show hosttopology;
// This is for sonoran code
// For Mojave use:
show controller[a] hostnvsrambyte[5,0];
show controller[a] hostnvsrambyte[5,1];
show controller[a] hostnvsrambyte[5,2];
// Byte 5,0 should be "L", 0x4c
// Byte 5,1 should be "N", 0x4e
// Byte 5,2 should be "X", 0x58


// Host Type definition INDEX of 5 should be for Linux
// Allow Reservations on unowned luns
set controller[a] HostNVSRAMByte[5,25]=1;
// Allow propagated host bus resets
set controller[a] HostNVSRAMByte[5,27]=1;
// Allow Reservations on unowned luns
set controller[b] HostNVSRAMByte[5,25]=1;
// Allow propagated host bus resets
set controller[b] HostNVSRAMByte[5,27]=1;
```

2. Using FAStT Storage Manager, look at **Storage System** > **Profile** and be sure that `Index 5 (DEFAULT)` shows `Name: Linux` and `ADT Status: Enabled`.

3. In Enterprise Management, choose **Tools** > **Execute Script**. The Script Editor opens.
4. In the Script Editor, choose **File** > **Load Script**. Browse to `LinuxCluster.scr` and load it.
5. Use `Tools` > V**erify and Execute** to run the script.

CHAPTER 11

Networking

This section contains the following:

- Setting the MAC Address Manually for a Virtual Machine on page 362
- The VMkernel Network Card Locator on page 365
- Forcing the Network Driver to Use a Specific Speed on page 367
- Enabling a Virtual Adapter to Use Promiscuous Mode on page 368
- Sharing Network Adapters and Virtual Networks on page 369
- Allowing the Service Console to Use the Virtual Machines' Devices on page 369
- Using Virtual Switches on page 373
- Troubleshooting on page 379

Setting the MAC Address Manually for a Virtual Machine

VMware ESX Server automatically generates MAC addresses for the virtual network adapters in each virtual machine. In most cases, these MAC addresses are appropriate. However, there may be times when you need to set a virtual network adapter's MAC address manually — for example:

- Virtual network adapters on different physical servers share the same subnet and are assigned the same MAC address, causing a conflict.
- You want to ensure that a virtual network adapter always has the same MAC address.

This document explains how VMware ESX Server generates MAC addresses and how you can set the MAC address for a virtual network adapter manually.

How VMware ESX Server Generates MAC Addresses

Each virtual network adapter in a virtual machine gets its own unique MAC address. ESX Server attempts to ensure that the network adapters for each virtual machine that are on the same subnet have unique MAC addresses. The algorithm used by ESX Server puts a limit on how many virtual machines can be running and suspended at once on a given machine. It also does not handle all cases when virtual machines on distinct physical machines share a subnet.

A MAC address is a six-byte number. Each network adapter manufacturer gets a unique three-byte prefix called an OUI — organizationally unique identifier — that it can use to generate unique MAC addresses. VMware has two OUIs — one for automatically generated MAC addresses and one for manually set addresses.

The VMware OUI for automatically generated MAC addresses is 00:0C:29. Thus the first three bytes of the MAC address that is automatically generated for each virtual network adapter have this value. ESX Server then uses a MAC address generation algorithm to produce the other three bytes. The algorithm guarantees unique MAC addresses within a machine and attempts to provide unique MAC addresses between ESX Server machines.

The algorithm that ESX Server uses is the following:

We use the VMware UUID (Universally Unique Identifier) to generate MAC addresses. We then check for any conflicts. If there is a conflict, we add an offset and check again, until there is no conflict. (The VMware UUID is based on the path to the virtual machine and the host's SMBIOS UUID.)

Once the MAC address has been generated, it does not change, unless the virtual machine is moved to a different location; for example, a different path on the same server or a different ESX Server machine. We save the MAC address in the configuration file of the virtual machine.

ESX Server keeps track of all MAC addresses that have been assigned to network adapters of running and suspended virtual machines on a given physical machine. ESX Server ensures that the virtual network adapters of all of these virtual machines have unique MAC addresses.

The MAC address of a powered-off virtual machine is not checked against running or suspended virtual machines. Therefore it is possible, but unlikely, that when a virtual machine is powered on again, it can get a different MAC address. This is due to a conflict with a virtual machine that was powered on when this virtual machine was powered off.

Setting MAC Addresses Manually

In order to work around both the limit of 256 virtual network adapters per physical machine and possible MAC address conflicts between virtual machines, the MAC addresses can be assigned manually by system administrators. VMware uses a different OUI for manually generated addresses: 00:50:56. The MAC address range is 00:50:56:00:00:00-00:50:56:3F:FF:FF.

You can set the addresses by adding the following line to a virtual machine's configuration file:

```
ethernet<number>.address = 00:50:56:XX:YY:ZZ
```

where <number> refers to the number of the Ethernet adapter, `XX` is a valid hex number between 00 and 3F, and `YY` and `ZZ` are valid hex numbers between 00 and FF. The value for `XX` must not be greater than 3F in order to avoid conflict with MAC addresses that are generated by the VMware Workstation and VMware GSX Server products. Thus the maximum value for a manually generated MAC address is

```
ethernet<number>.address = 00:50:56:3F:FF:FF
```

You must also set the option in a virtual machine's configuration file:

```
ethernet<number>.addressType="static"
```

VMware ESX Server virtual machines do not support arbitrary MAC addresses, hence the above format must be used. So long as you choose `XX:YY:ZZ` uniquely among your hard-coded addresses, conflicts between the automatically assigned MAC addresses and the manually assigned ones should never occur.

Using MAC Addresses

The easiest way to familiarize yourself with MAC addresses is to set the MAC address statically, then remove the virtual machine configuration file options `ethernet<number>.address`, `ethernet<number>.addressType` and `ethernet<number>.generatedAddressOffset`. Check to see that the virtual machine gets a generated MAC address.

We cannot guarantee that a host stays within a specific MAC address range. However, we guarantee that the MAC address never conflicts with any physical host by using our OUIs (00:0C:29 and 00:50:56), that are unique to virtual machines.

The VMkernel Network Card Locator

When network interface cards are assigned to the VMkernel, sometimes it is difficult to map from the name of the VMkernel device to the physical network adapter on the machine.

For example, if there are four Intel EEPro cards in a machine and all are dedicated to the VMkernel, these four cards are called `vmnic0`, `vmnic1`, `vmnic2` and `vmnic3`. The name of a card is based on its order in the PCI bus/slot hierarchy on the machine — the lower the bus and slot, the lower the number at the end of the name.

If there is more that one type of network interface card, then the first driver that is loaded claims its virtual NICs (`vmnic`) in PCI slot order, then the next driver that is loaded claims its virtual NICs (`vmnic`) in PCI slot order, and so on.

This naming policy is also valid for the functions within a slot for multifunction devices, for example, a dual port NIC which occupies a single slot but has two functions: bus1.slot1.function1 and bus1.slot1.function2. The functions are enumerated for each slot in the same way that the slots are enumerated for each device type.

findnic Command

If you know the bus and slot order of the adapters, you can figure out which adapter has which name. However, if you don't, you can use the `findnic` program to help you make the proper association of network adapter to name.

The format of the command is

```
findnic <options> <nic-name> <local-ip> <remote-ip>
```

The `findnic` program takes a VMkernel network device name, an IP address to give the device on the local machine and an IP address that `findnic` should try to ping. When you issue the command, `findnic` pings the remote IP address.

This allows you to determine which adapter is which by looking at the LEDs on the cards to see which one has flashing lights or by seeing if the ping itself is successful.

Options

`-f`
Do a flood ping.

`-i <seconds>`
Interval in seconds between pings.

Examples

`findnic vmnic0 10.2.0.5 10.2.0.4`
Binds VMkernel device `vmnic0` to IP address 10.2.0.5 and then tries to ping the remote machine with the IP address 10.2.0.4.

`findnic -f vmnic1 10.2.0.5 10.2.0.4`
Binds VMkernel device `vmnic1` to IP address 10.2.0.5, then tries to flood ping the remote machine with the IP address 10.2.0.4.

Forcing the Network Driver to Use a Specific Speed

The VMkernel network device drivers start with a default setting of Autonegotiate. This setting will work correctly with network switches set to autonegotiate. If your switch is configured for a specific speed and duplex setting, you must force the network driver to use the same speed and duplex setting.

If you encounter problems — in particular, very low bandwidth — it is likely that the NIC did not autonegotiate properly and you should configure the speed and duplex settings manually.

To resolve the problem, either change the settings on your switch or change the settings for the VMkernel network device using the VMware Management Interface.

1. Log in to the management interface as root.
2. Click on the **Options** tab.
3. Click **Network Connections**.
4. Locate the device you want to reconfigure and choose the appropriate setting from the drop-down list for **Configured Speed, Duplex**.
5. Click **OK**.

Note: Changing the network speed settings only takes effect after a reboot.

Enabling a Virtual Adapter to Use Promiscuous Mode

For security reasons, guest operating systems are not normally allowed to set their virtual Ethernet adapters to use promiscuous mode.

In some circumstances, you may need to use the virtual Ethernet adapters in promiscuous mode. To enable this use, you must set the `PromiscuousAllowed` configuration variable to `yes`. To do so, follow these steps.

1. Check the Edit Configuration page of the VMware Management Interface to determine what network the virtual Ethernet adapter is using. For this example, assume that the Networking section of the page shows the adapter is using `vmnic0`.
2. Log in to the server's service console and enter the following command:

   ```
   echo "PromiscuousAllowed yes" > /proc/vmware/net/vmnic0/config
   ```

   This allows the guest operating systems in all virtual machines using `vmnic0` to enable promiscuous mode.

   If the adapter is using a different network, such as `vmnet_0`, make the appropriate substitution in the command.
3. Take the appropriate steps in the guest operating system to enable promiscuous mode on the virtual network adapter.

You may want to allow only some adapters on a particular network to use promiscuous mode. In that case, you can selectively disable promiscuous mode based on the MAC address of the virtual machine's Ethernet adapter. Perform the following:

1. Connect to the virtual machine with the remote console and use the appropriate guest operating system tools to determine the MAC address of the virtual Ethernet adapter.
2. Log in to the service console and enter the following command:

   ```
   echo "PromiscuousAllowed no" > /proc/vmware/net/vmnic0/<MACAddress>
   ```

   In place of `<MACAddress>`, substitute the virtual Ethernet adapter's MAC address in the standard format `00:05:69:XX:YY:ZZ`. If the adapter is using a different network, such as `vmnet_0`, make the appropriate substitution in the command.

Sharing Network Adapters and Virtual Networks

In many ESX Server configurations, there is a clear distinction between networking resources used by the virtual machines and those used by the service console. This may be important for security reasons, for example — isolating the management network from the network used by applications in the virtual machines.

However, there may be times when you want to share resources, including physical network adapters and virtual networks.

This technical note provides instructions on sharing in both directions — making the virtual machines' resources available to the service console and allowing virtual machines to share the network adapter used by the service console.

This sharing is made possible by the `vmxnet_console` driver, which is installed with the service console.

Caution: We recommend that only advanced users make these configuration changes. The steps below are easier for someone who is familiar with administering a Linux system.

Note: If you accidentally bring down the local loopback interface while you are reconfiguring network devices, the VMware Management Interface does not function properly. To bring it back up, use the command `ifconfig lo up`.

Allowing the Service Console to Use the Virtual Machines' Devices

All network adapters used by virtual machines (that is, assigned to the VMkernel) and virtual networks can be made accessible to the service console. Virtual networks — identified as `vmnet_<n>` on the Edit Configuration page of the VMware Management Interface — provide high-speed connections among virtual machines on the same physical server.

To give the service console access to VMkernel network adapters and virtual networks, you must install the `vmxnet_console` module. When you install it, you provide a list of VMkernel network adapters and virtual networks that the `vmxnet_console` module should attach to. For example, if the VMkernel had an adapter named `vmnic1` and a virtual network named `vmnet_0` and you wanted to provide access to them from the service console, you would use the following command to install the `vmxnet_console` module.

```
insmod vmxnet_console devName="vmnic1;vmnet_0"
```

The `devName` parameter is a comma-separated list of names of VMkernel network adapters and virtual networks.

When you install the module, it adds the appropriate number of `eth<n>` devices on the service console in the order that you list the VMkernel network adapter and virtual network names after the `devName` parameter. In the example above, if the service console already had a network adapter named `eth0`, when you load `vmxnet_console` with `vmnic1` and `vmnet_0`; `vmnic1` is seen as `eth1` on the service console and `vmnet_0` is seen as `eth2`.

Once the `eth<n>` devices are created on the service console, you can bring the interfaces up in the normal manner. For example, if you want the service console to use IP address 10.2.0.4 for the network accessed via the `vmnic1` adapter, use the following command:

```
ifconfig eth1 up 10.2.0.4
```

If you want an easy way to see which `eth<n>` devices are added by the `insmod` command, you can add the `tagName` parameter to the `insmod` command, as shown in this example:

```
insmod vmxnet_console devName="vmnic1;vmnet_0"
tagName=<tag>
```

In this case the `vmxnet_console` module adds the names of each of the `eth<n>` devices that it created to `/var/log/messages`. Each message begins with the string `<tag>`.

To figure out the names of the devices that were added, use this command:

```
grep <tag> /var/log/messages
```

Starting Shared VMkernel Network Adapters and Virtual Networks when the Service Console Boots

There are two ways you can configure the service console to start VMkernel network adapters when the service console boots. The simpler case involves sharing a network adapter other than `eth0`. Sharing `eth0` is more complicated and is described later.

Continuing with the example from the previous section, you can append the following lines to `/etc/rc.d/rc.local`:

```
insmod vmxnet_console devName="vmnic1;vmnet_0"
ifconfig eth1 up 10.2.0.4
ifconfig eth2 up 63.93.12.47
```

Another method is to set up the files `/etc/sysconfig/network-scripts/ifcfg-eth1` and `/etc/sysconfig/network-scripts/ifcfg-eth2` with the appropriate network information. And be sure the `ONBOOT=` line is `ONBOOT=yes`. The `ifcfg-eth1` file for this example would be

```
DEVICE=eth1
BOOTPROTO=static
BROADCAST=10.255.255.255
IPADDR=10.2.0.4
NETMASK=255.0.0.0
NETWORK=10.0.0.0
ONBOOT=yes
```

In this case, the lines you add to `/etc/rc.d/rc.local` would be:

```
insmod vmxnet_console devName="vmnic1;vmnet_0"
ifup eth1
ifup eth2
```

Sharing the Service Console's Network Adapter with Virtual Machines

Caution: If you intend to share the adapter that is `eth0` on the service console, be careful as you implement the following steps. In order to configure ESX Server initially, you need to have a network connection. Once the initial configuration is set, you make several changes. At one point in the process, there is no network connection to the service console, and you must work directly at the server.

When you first install and configure ESX Server, the VMkernel is not loaded, so the service console needs to control the network adapter that is `eth0`. When you configure ESX Server, assign the adapter that is `eth0` to the service console.

Once you have completely configured ESX Server properly and rebooted the machine, the VMkernel is loaded. At that point, you need to take the following steps:

1. Edit `/etc/modules.conf` and comment out the line that refers to `alias eth0`.

   If the original line is
   `alias eth0 e100`
   edit it to be
   `# alias eth0 e100`

   This disables `eth0` on the service console when it boots.

2. Use the VMware Management Interface to reconfigure the server. Log in as root and go to `http://<hostname>/pcidivy`, then click the **Edit** link for the

configuration you want to change. Find the table row that lists the Ethernet controller assigned to the console and click the radio button in the Virtual Machine column to reassign it.

Click **Save Configuration**, then reboot the machine when prompted.

3. When the machine reboots, no network adapter is assigned to the service console, so you must do this step at the server.

   Add the appropriate lines to `/etc/rc.d/rc.local`. For example, if `eth0` is the only network adapter that you intend to share between the VMkernel and the service console, and if it is named `vmnic0` in the VMkernel, you add the lines

   ```
   insmod vmxnet_console devName="vmnic0"
   ifup eth0
   ```

   If you are unsure what name the VMkernel has assigned to the network adapter that formerly was `eth0` in the service console, you can determine its name using the `findnic` program (see The VMkernel Network Card Locator on page 365).

   Note: The adapter you wish to share may be assigned to an adapter bond. If so, you need to specify the bond name, of the form `bond<n>`, instead of the adapter name. See Finding Bonds and Adapters in the Service Console on page 374 for instructions on how to find a bond name.

4. The next time you reboot the system, the network adapter is shared by the service console and the virtual machines.

   To begin sharing the network adapter without rebooting the system, you can manually issue the same commands you added to `/etc/rc.d/rc.local`:

   ```
   insmod vmxnet_console devName="vmnic0"
   ifup eth0
   ```

Using Virtual Switches

ESX Server allows you to create abstracted network devices called virtual ethernet switches. Each virtual switch is a network hub that can be used by virtual machines. A virtual switch can route traffic internally between virtual machines, or link to external networks.

Virtual switches can be used to combine the bandwidth of multiple network adapters and balance communications traffic among them. They can also be configured to maintain persistent network connections despite link failures for individual adapters.

A virtual switch models a physical ethernet switch. A virtual switch contains 32 logical ports. You can connect one network adapter of a virtual machine to each port.

Each virtual switch can also have one or more port groups assigned to it. For more information on port groups, see Creating Port Groups on page 220.

Choosing a Network Label

ESX Server uses network labels to represent network connections to virtual machines. The network label is intended to be a functional descriptor for the network connection. ESX Server represents both virtual switches and port groups to virtual machines by assigning them a network label.

You can only change the network label for a switch when it is not being used by a virtual machine.

Binding Physical Adapters

You can group physical adapters by "binding" them together. This is the functional equivalent for NIC teaming in ESX Server. Certain options you can configure through the Service Console refer to grouped adapters as a "bond".

You should bind together similar physical adapters whenever possible. ESX Server uses only features or capabilities common to all adapters when defining the functionality of a bonded switch. For example, ESX Server can use a hardware acceleration feature for a bond only if all adapters in the bond include that feature.

Hardware acceleration features supported by ESX Server include:

- VLAN tag handling
- Checksum calculations
- TCP Segmentation Offloading

Binding together identical models of physical adapters ensures that all features of the adapter can be used by ESX Server.

When you choose a network connection for a virtual machine, ESX Server links it to the associated virtual switch. The operation of the virtual machine depends on the configuration of its network connection. Thus, you cannot bind or detach physical adapters while a virtual switch is being used by a virtual machine.

You can bind up to ten physical adapters to each virtual switch.

Finding Bonds and Adapters in the Service Console

When you bind together adapters in a virtual switch, ESX Server assigns a bond number identifying the new logical grouping of physical adapters. You will need to know the bond number in order to configure the bond options described below. Check `/etc/vmware/netmap.conf` to determine the bond number assigned to a virtual switch.

You may also need to know the device name ESX Server assigns to a physical adapter. Certain options use the device name to designate a specific adapter. ESX Server defines device names with the string `vmnic<n>`, for which `<n>` is the same adapter number displayed for an adapter in the Management Interface. For example, the physical adapter identified as **Outbound Adapter 1** would have the device name `vmnic1`.

You can also determine the device name by searching `/etc/vmware/devnames.conf` for the name definition. Note the PCI bus address of the adapter in the Management Interface and search for the corresponding name definition. For example, to find the device name for the adapter at **PCI 2:4.0**:

1. Log into the Service Console.
2. Search `/etc/vmware/devnames.conf`:

```
$ grep 2:04.0 /etc/vmware/devnames.conf
002:04.0 nic vmnic0
```

The device name is `vmnic0`.

Creating a Virtual Switch

You can find basic instructions for creating and modifying virtual switches in Changing Network Connections on page 219.

Note: The configuration options described below are used for optimizing virtual switches for complex operating conditions. You can create and use a virtual switch without changing these options for most configurations.

Choosing a Load Balancing Mode

You can choose one of three modes for determining how ESX Server distributes traffic among the network adapters assigned to a virtual switch:

- MAC address balancing
- IP address balancing
- Standby

You select the load balancing mode by setting the `load_balance_mode` option for a virtual switch. All options for virtual switches are defined in `/etc/vmware/hwconfig`, which you can modify through the Service Console.

MAC address load balancing distributes networking traffic based on the MAC hardware addresses of the source network adapters. Select MAC address balancing by setting `load_balance_mode` to `out-mac`.

Note: MAC address balancing is the default load balancing mode in ESX Server.

IP address load balancing distributes networking traffic based on IP addresses. ESX Server distributes network traffic not using the IP protocol on a fixed-volume sequential cycle. Select IP address balancing by setting `load_balance_mode` to `out-ip`.

Standby mode designates a specific adapter to use as the primary connection. Use Standby mode for redundant connection switches, as described in the next section.

This example describes how to set the load balancing mode for `bond1` to IP address load balancing:

1. Log into the Service Console as `root`.
2. Edit `/etc/vmware/hwconfig`.
3. Define the load balancing mode for `bond1`:

   ```
   nicteam.bond1.load_balance_mode = "out-ip"
   ```

   If you previously defined the option for this switch, just change the current mode value to `out-ip`.
4. Save the file and close it.

Configuring the Bond Failure Mode

You can select one physical adapter to be the primary network connection for a virtual switch. In this configuration, ESX Server routes all traffic through the primary adapter and reserves the other adapters in case of connection failure. This type of redundant connection switch is defined as using a "failover" configuration.

Select a primary adapter by setting the `home_link` option for a virtual switch:

1. Log into the Service Console as `root`.
2. Edit `/etc/vmware/hwconfig`.
3. Define the primary adapter. For example, to choose `vmnic2` for `bond1`:

   ```
   nicteam.bond1.home_link = "vmnic2"
   ```

   If you previously defined the option for this switch, just change the current mode value to `vmnic2`.
4. Save the file and close it.

Note: Designating a primary link for a virtual switch overrides the load balancing mode. If you set the `home_link` option, ESX Server ignores the value of `load_balance_mode`.

ESX Server monitors the primary link for physical connection failures. When the primary adapter loses contact, ESX Server transfers the network traffic to one of the secondary adapters while continuing to monitor the primary adapter. When ESX Server detects that the physical connection of the primary link has been restored, it transfers the connection for the virtual switch back to the primary.

This basic failure detection mode passively monitors an adapter for loss of physical connection to an external switch. You can configure ESX Server to actively search for network failures using beacon monitoring.

Using Beacon Monitoring

The beacon monitoring feature broadcasts beacon packets on the external network linked to the server to detect distributed connection failures. ESX Server issues beacon packets from one adapter addressed to other adapters assigned to a virtual switch. By monitoring beacon reception, the server can determine the state of connections in a multi-point network route. You can configure beacon monitoring for each virtual switch and for the entire server.

Beacon monitoring is designed to be used in configurations where the multiple adapters assigned to a virtual switch are connected to more than one external switch. Physical link monitoring only indicates whether an adapter is communicating with one external switch. Beacon failures can detect connection failures between external switches or routing errors among switches in a distributed network domain.

ESX Server uses beacon monitoring as a variable indicator of network connection failure. The server indicates a connection loss after it fails to receive a set number of broadcast beacons in succession. Only when the number of failed beacons exceeds

the failure threshold will the server identify a link as disconnected and switch to another adapter.

By default, the beacon failure threshold is set to zero for each virtual switch. You can enable beacon monitoring by setting the failure threshold to two or greater.

ESX Server also allows you to determine the frequency with which it issues beacons. The rate at which the server broadcasts beacons, in conjunction with the failure threshold, determines the total monitoring interval before the server identifies a link as isolated:

> Beacon Interval (in seconds) X Beacon Failure Threshold = Total Beacon Failure Interval

You set the failure threshold for an individual switch with the `switch_failover_threshold` option. This example describes how to set the failure threshold for `bond1` to 2 beacons:

1. Log into the Service Console as `root`.
2. Edit `/etc/vmware/hwconfig`.
3. Set the beacon failure threshold for `bond1`:

   ```
   nicteam.bond1.switch_failover_threshold = "2"
   ```

4. Save the file and close it.

ESX server broadcasts beacons with the same frequency for all switches. The **SwitchFailoverBeaconInterval** option sets this value. The server also defines an overall failure threshold for all switches with the **SwitchFailoverThreshold** option, but `switch_failover_threshold` overrides this value for each individual switch.

You can set the values of the **SwitchFailoverBeaconInterval** and **SwitchFailoverThreshold** options in the **Advanced Settings** panel of the Management Interface. See Changing Advanced Settings on page 242 for details.

Beacon monitoring can cause false indications of network connection failure. External switches may trap beacon packets, causing ESX Server to declare a switch failure for a connection that is functioning normally. When the the server switches to a secondary link, traffic from the primary may still be transmitted because the connection has not actually failed. This can result in an external switch receiving duplicate packets from both links.

Note: ESX Server uses beacon monitoring as a secondary method to detect network failures. When the server detects a physical link failure for the primary adapter, it will switch to a secondary adapter without regard to whether beacon monitoring indicates a failed connection.

Using Beacon Monitoring with a Port Group

You can enable beacon monitoring for a port group with the **SwitchFailoverBeaconVlanID** option. If you select a port group with this option, ESX Server broadcasts monitor beacons tagged with the **VLAN ID** of that port group. This effectively limits the server to monitoring connection failures within the external VLAN.

You can set the value of the **SwitchFailoverBeaconVlanID** in the **Advanced Settings...** panel of the Management Interface. See Changing Advanced Settings on page 242 for details.

Note: The value of **SwitchFailoverBeaconVlanID** applies to all virtual switches. You cannot choose a separate VLAN to monitor for each switch.

Configuring External Network Switches

- IP Load Balancing — With this load balancing mode enabled, ESX Server may present duplicate MAC addresses to an external network switch. The external switch should be set static 802.3ad (EtherChannel) mode to avoid external routing errors.
- **SwitchFailoverBeaconEtherType** — This option sets the Ether type of monitor beacons. You may wish to change this value so that your external switches correctly handle monitor beacons.
- Beacon Monitoring with Multiple Switches — All external switches connected to a virtual switch using beacon monitoring must be within the same network broadcast domain.
- Spanning-Tree Protocol — If an adapter loses the physical connection to an external switch that is using the Spanning-Tree Protocol, the switch may induce a delay in reconnecting the link while it applies the protocol to check for duplicate active connections. ESX Server can only detect that the link has been physically restored, but not that the port is blocked by the Spanning-Tree check.
- Portfast Mode — You can use the Portfast mode to reduce errors caused by Spanning-Tree checks. If you cannot disable the Spanning-Tree Protocol for an external switch, configure the ports connected to the server to use Portfast mode. This reduces Spanning-Tree delays, resulting in fewer false indications of link failures.

Troubleshooting

If, while booting your virtual machine, you see an error message stating that the Ethernet device cannot be detected, then check the following:

- Network Connections page — Be sure that the correct physical adapters are assigned to a bond
- VM Configuration page — Be sure the correct bond is selected for the specified Ethernet device and that the selected `vmnic` is not already assigned to a bond device or already in use.

Make the appropriate change(s), then reboot your virtual machine to see if the error message persists.

CHAPTER 12

VMware ESX Server Resource Management

VMware ESX Server allows you to optimize the performance of your virtual machines by managing a virtual machine's resource allocations. You can control a virtual machine's access to:

- CPU time
- Memory space
- Network bandwidth
- Disk bandwidth

Note: You must be the root user to manage virtual machine resources.

You can manage virtual machine resource allocations through the VMware Management Interface, from the `procfs` interface on the service console, and the VMware Scripting API. The first two methods are covered in this chapter, while the Scripting API is described in the *VMware Scripting API User's Manual* at *www.vmware.com/support/developer.*

This chapter contains the following sections:

- Virtual Machine Resource Management on page 383
- Using ESX Server Resource Variables on page 384
- Improving Performance on page 386
- CPU Resource Management on page 388
- Managing Virtual Machine CPU Resources on page 394
- Memory Resource Management on page 403
- Managing Virtual Machine Memory on page 410
- Using Your NUMA System on page 418
- Sizing Memory on the Server on page 424
- Managing Disk Bandwidth on page 432
- Managing Network Bandwidth on page 428

Virtual Machine Resource Management

ESX Server uses a proportional share mechanism to allocate CPU, memory, and disk resources when multiple virtual machines are contending for the same resource. Network bandwidth is controlled with network traffic shaping.

CPU and memory resource each offer an additional dimension of control. For CPU management, you can specify a minimum and maximum percentage of a single physical CPU's processing power for each virtual machine. You may also specify CPU shares and restrict a virtual machine to run on a certain set of physical CPUs (CPU scheduling affinity). For more information, see Admission Control Policy on page 389.

Similarly, you may specify minimum and maximum memory sizes, as well as memory shares, for each virtual machine. Your level of control is greatly impaired, however, if you fail to install VMware Tools in each virtual machine or if you fail to set up the VMkernel swap space. For more information, see Allocating Memory Resources on page 403.

Note: You should not have to adjust resources for every virtual machine you create. We suggest that you determine which virtual machines are performance sensitive and adjust these accordingly.

Service Console Resource Management

The service console receives 2000 CPU shares and has a minimum CPU percentage of 8 percent, by default. In most cases, this should be an appropriate allocation, since the service console should not be used for CPU-intensive tasks.

If you do find it necessary to adjust the service console's allocation of CPU shares, you can use the VMware Management Interface. See Configuring the Service Console on page 220.

Depending on the number of virtual machines you plan to run concurrently, we have approximate guidelines for the memory you should allocate to the service console. For more information, see Service Console Memory on page 424.

Using ESX Server Resource Variables

The majority of this chapter describes the different parameters you can use to optimize resources on ESX Server. We include information on the various algorithms and policies ESX Server uses to determine resource allocation.

Note: In the next section, we provide a practical description of resource optimization, based on the behavior of ESX Server and its virtual machines. We provide some general guidelines on deciding what resource variables to optimize and other general tips to improve performance on ESX Server.

This chapter contains the following:

- Improving Performance on page 386
- CPU Resource Management on page 388
  - Allocating CPU Resources on page 388
  - Admission Control Policy on page 389
  - Specifying Minimum and Maximum CPU Percentages on page 389
  - Using Proportional-share Scheduling by Allocating Shares on page 391
  - Managing CPU Time with Percentages and Shares on page 392
- Managing Virtual Machine CPU Resources on page 394
  - Managing CPU Resources from the Management Interface on page 394
  - Managing CPU Resources from the Service Console on page 395
- Memory Resource Management on page 403
  - Allocating Memory Resources on page 403
  - Admission Control Policy on page 405
  - Allocating Memory Dynamically on page 406
  - Reclaiming Memory from Virtual Machines on page 407
  - Sharing Memory Across Virtual Machines on page 408
- Managing Virtual Machine Memory on page 410
  - Managing Memory Resources from the Management Interface on page 410
  - Managing Memory Resources from the Service Console on page 411
- Using Your NUMA System on page 418
  - NUMA Configuration Information on page 418

- Automatic NUMA Optimizations on page 420
- Manual NUMA Optimizations on page 420

- Sizing Memory on the Server on page 424
  - Server Memory on page 424
  - Service Console Memory on page 424
  - Virtual Machine Memory Pool on page 424
  - Virtual Machine Memory on page 425
  - Memory Sharing on page 425
  - Memory Overcommitment on page 426
  - Example: Web Server Consolidation on page 427
- Managing Network Bandwidth on page 428
  - Using Network Filters on page 428
  - Managing Network Bandwidth from the Management Interface on page 428
  - Managing Network Bandwidth from the Service Console on page 429
  - Traffic Shaping with nfshaper on page 430
- Managing Disk Bandwidth on page 432
  - Managing Disk Bandwidth from the Management Interface on page 433
  - Managing Disk Bandwidth from the Service Console on page 434

Improving Performance

Before deploying all your virtual machines, we suggest that you create a list of all the virtual machines you plan to run on ESX Server. For each virtual machine, identify its primary functions and applications. Based on its primary function, determine its limiting resources. For example, a Web server's most limiting resource may be memory, while a terminal services server's most limiting resource may be CPU. Similarly, a database server's most limiting resource may be disk bandwidth.

In this section, we provide some general guidelines on improving performance on 'VMware ESX Server. However, some of these guidelines may not be appropriate for you, depending on your particular workplace situation.

Note: Determine which virtual machines are more important and which ones will benefit more from additional resources. You should not need to optimize each resource for each virtual machine.

For example, you may want to give more memory shares and a higher memory minimum to a virtual machine Web server for Platinum customers, compared to a virtual machine Web server for Silver customers or for an internal Web server.

Note: If you run several virtual machines with similar guest operating systems on ESX Server, then likely, you will be able to have a higher overcommitment of memory, without noticing a performance degradation in ESX Server. In general, similar guest operating systems enable greater memory sharing in virtual machines. See Sharing Memory Across Virtual Machines on page 408.

Improving Slow Performance

If performance seems slow, first determine whether this slow performance applies to all virtual machines on an ESX Server, or to just one virtual machine.

Improving Slow Performance on ESX Server

If you notice slow performance on all your virtual machines, then examine CPU usage. Check and see how much idle time each processor has. Also, check overall system CPU utilization through the VMware Management Interface. If the processors are not taxed, and total system CPU utilization is under 80%, then the problem is probably not CPU usage.

If CPU resources are not the problem, then check if the VMkernel is swapping out memory. Check the output of `/proc/vmware/sched/mem` from the `procfs` interface in the service console. For more information, see Service Console Commands on page 412.

If the problem is VMkernel swapping, then check and make sure VMware Tools is installed. Place the swap file in a different physical drive than the virtual disks. You may also consider adding more physical memory to the server, or possibly migrating some virtual machines onto another ESX Server.

Improving Slow Performance on Virtual Machines

If slow performance is isolated on just a few virtual machines, then you should first check their resource utilization before examining the service console.

Note:

Determine if the guest operating system is doing a lot of paging (swapping).

- In a Linux guest operating system, run the `vmstat` command. For more information, see the `vmstat(8)` man page.
- In a Windows guest operating system, open the **Control Panel**. Double-click **Administrative Tools**, then double-click **Performance**. Check the value for pages/second.

If a virtual machine is paging a lot, then increase the minimum memory so that excessive paging is eliminated. If you're close to the maximum memory size, then also increase that resource setting.

Optimizing Performance on the Service Console

If the problem is with CPU resources, then increase the CPU minimum of the service console and see if that solves the problem.

You can also improve performance by not connecting unnecessarily through the remote console. For example, unless you are performing an action in a virtual machine, close the remote console. Having a remote console window open, without any activity, still uses CPU resources in the service console.

To optimize performance, you can use other third-party software, such as Virtual Network Computing (VNC) viewer or Microsoft Terminal Services to connect to your virtual machine, without consuming CPU resources in the service console.

CPU Resource Management

VMware ESX Server provides dynamic control over both the execution rate and the processor assignment of each scheduled virtual machine. The ESX Server scheduler performs automatic load balancing on multiprocessor systems.

You can manage the CPU resources on a server from the VMware Management Interface, from the `procfs` interface on the service console and the VMware Scripting API.

For each virtual machine, you can define a minimum and maximum amount of CPU that a virtual machine can use, guaranteeing a percentage of the CPU resource, whether or not there is contention. You also allocate CPU shares to specify the relative importance of virtual machines.

If you have also purchased the VMware Virtual SMP for ESX Server product and your guest operating system is SMP-capable, then you can also control whether the virtual machine runs on one or two CPUs, and restrict a virtual machine to run only on certain physical CPUs. For more information on the VMware Virtual SMP for ESX Server product, contact VMware, Inc. or your authorized sales representative.

For additional information on CPU management by VMware ESX Server, see the `cpu(8)` man page.

Allocating CPU Resources

Three basic parameters control the allocation of CPU resources to each virtual machine:

- Its minimum rate — min

  The minimum CPU percentage represents an absolute fixed lower limit of a single physical CPU's processing power. The virtual machine will always be able to use this minimum percentage of a CPU's resources, regardless of what else is happening on the server. The system uses an admission control policy to enforce this guarantee. You cannot power on a new virtual machine if it is not possible to reserve its minimum CPU percentage.

- Its maximum rate — max

  The maximum CPU percentage represents an absolute fixed upper limit on the consumption of a single physical CPU's processing power. The virtual machine will never consume more than this maximum percentage of a CPU's resources, even if there is idle time on the system.

- Its shares allocation

CPU shares entitle a virtual machine to a relative fraction of CPU resources. For example, a virtual machine that has twice as many shares as another is generally entitled to consume twice as much CPU time, subject to their respective minimum and maximum percentages.

You may specify shares by specifying a numerical value, or specifying **high**, **normal**, or **low**. By default, the setting for **normal** shares is twice that of **low**. Similarly, **high** shares are twice that of **normal** (or four times that of **low**).

You have the option of specifying a minimum percentage, a maximum percentage, CPU shares, or a combination of these. The system automatically allocates CPU time to each virtual machine somewhere between its minimum and maximum percentages, refined by the number of shares.

Admission Control Policy

ESX Server uses an admission control policy. While CPU reservations are used for admission control, actual CPU time allocations vary dynamically, and unused reservations are not wasted.

Note: If ESX Server is unable to guarantee a virtual machine's specified minimum percentage, it will not allow you to power on that virtual machine.

Over the next few sections, we discuss managing CPU resources using CPU percentages, CPU shares, and scheduling affinity by assigning virtual machines to run on specific processors.

- Specifying Minimum and Maximum CPU Percentages on page 389
- Assigning Virtual Machines to Run on Specific Processors on page 390
- Using Proportional-share Scheduling by Allocating Shares on page 391
- Managing CPU Time with Percentages and Shares on page 392

Specifying Minimum and Maximum CPU Percentages

Starting with ESX Server 2.0, you have the option to specify a minimum and maximum percentage of CPU for each virtual machine. The minimum percentage represents an absolute, fixed lower limit while the maximum percentage represents an absolute, fixed upper limit. A virtual machine will always be able to use at least as much CPU time as specified by the minimum percentage, and never use more CPU time than the specified maximum percentage.

For a single virtual CPU virtual machine, the percentage ranges from 0% to 100%. For a dual-virtual CPU machine, the percentage ranges from 0% to 200%.

Note: Set a virtual machine's minimum for the minimal acceptable performance.

For example, if one of your virtual machines is running an important application, you can specify a higher minimum percentage for this virtual machine, compared to the other virtual machines on your ESX Server.

Note: You can set CPU percentages for some, or all of your virtual machines. Alternately, you may choose to set only minimum, or only maximum CPU percentages. You do not need to set both.

For example, you plan to run 20 virtual machines on your ESX Server machine, but have currently deployed only five virtual machines. Normally, these five virtual machines would utilize any extra CPU time that is available on the ESX Server machine. However, after you deploy an additional 15 virtual machines, these five initial virtual machines will receive a smaller share of CPU time, than what they were used to previously.

If you prefer not to have the users of these original five virtual machines become accustomed to this higher level of CPU time, you could set a maximum CPU percentage for these five virtual machines and limit the amount of CPU time they receive. Then, these users won't see a difference when you deploy the additional virtual machines.

Note: The CPU percentage(s) you choose represent an absolute fixed limit for that virtual machine.

Assigning Virtual Machines to Run on Specific Processors

In multiprocessor systems, you can also restrict the assignment of virtual machines to a subset of the available processors by specifying an affinity set for each virtual machine. The system automatically assigns each virtual machine to processors in the specified affinity set in order to achieve the CPU allocations specified by the minimum, maximum and shares settings associated with each virtual machine. If the affinity set for a uniprocessor virtual machine contains only a single processor, then the virtual machine is placed there.

As mentioned previously, the scheduler performs automatic load balancing of CPU time. To optimize this automatic load balancing, you should avoid manually specifying affinity for a virtual machine. Instead, we suggest setting a CPU minimum to guarantee the minimal acceptable performance for a virtual machine.

Note: By specifying a minimum (instead of specifying affinity), ESX Server has the maximum flexibility for automatic optimizations.

For more information, see Managing CPU Resources from the Management Interface on page 394.

You can modify CPU shares and affinity sets dynamically at any time by using the `procfs` interface on the service console or using the VMware Management Interface. Initial values for a virtual machine may also be specified in its configuration file.

Using Proportional-share Scheduling by Allocating Shares

With proportional-share processor scheduling, you can allocate a number of shares to each scheduled virtual machine. CPU shares are relative.

For example, a virtual machine that is allocated 2000 shares is entitled to consume twice as many CPU cycles as a virtual machine with 1000 shares. Similarly, a virtual machine that is allocated 200 shares is entitled to consume twice as many CPU cycles as a virtual machine with 100 shares. The number of shares may vary, but the first virtual machine has twice as many shares as the second virtual machine.

By default, the setting for **high** is twice that of **normal**, or four times that of **low**. For example, a virtual machine with **high** shares can consume twice as many CPU cycles as a virtual machine with **normal** shares, or four times as many CPU cycles as a virtual machine with **low** shares. If you want to change these defaults, see Using procfs on page 397.

You can use proportional-share scheduling by itself, or in combination with CPU percentages. See Managing CPU Time with Percentages and Shares on page 392.

For example, if you are running three virtual machines, each starts with a default allocation of **normal** shares. If you want to give one virtual machine half the CPU time and give each of the other two virtual machines one-quarter of the CPU time, you can assign **high** shares to the first virtual machine and leave the other two at their default allocations. Since these share allocations are relative, the same effect may be achieved by giving 500 shares to the first virtual machine and 250 to each of the other two virtual machines.

Controlling Relative CPU Rates

You can control relative CPU rates by specifying the number of shares allocated to each virtual machine. Increasing the number of shares allocated to a virtual machine dilutes the effective value of all shares by increasing the total number of shares.

The service console receives 2000 shares and has a minimum CPU percentage of 8 percent, by default. In most cases, this should be an appropriate allocation, since the service console should not be used for CPU-intensive tasks.

If you do find it necessary to adjust the service console's allocation of CPU shares, you can use the VMware Management Interface or the `procfs` interface on the service console, as described in this section. Through the management interface, you can

increase the minimum CPU percentage or the number of CPU shares to allocated more CPU to the service console. For more information, see Configuring the Service Console on page 220.

Note: CPU share allocations, by themselves, do not necessarily guarantee the rate of progress within a virtual machine.

For example, suppose virtual machine A is allocated **high** shares, while virtual machine B is allocated **normal** shares. If both virtual machines are CPU-bound — for example, both are running the same compute-intensive benchmark — then virtual machine A should indeed run twice as fast as virtual machine B. However, if virtual machine A instead runs an I/O-bound workload that causes it to stop as it waits for other resources, it does not run twice as fast as virtual machine B, even though it is allowed to use twice as much CPU time.

Managing CPU Time with Percentages and Shares

You can also use both CPU percentages and shares to manage CPU resources for your virtual machines. CPU percentages specify absolutes, an absolute minimum or maximum usage by a virtual machine. Shares, on the other hand, represent relative importance or priority. You set shares to specify which virtual machines will get preferential treatment when ESX Server is constrained.

For example, virtual machine A has a minimum CPU percentage of 20%, and a maximum CPU percentage of 50%, while virtual machine B has a minimum percentage of 30% and no specified maximum percentage. You then decide to give virtual machine A **high** CPU shares and virtual machine B **low** CPU shares.

ESX Server interprets this allocation so that virtual machine A will never have less than 20% of a single physical CPU, while virtual machine B will never have less than 30% of a single physical CPU, in any situation.

However, if one or more virtual machines are idling, then ESX Server redistributes this extra CPU time proportionally, based on the virtual machines' CPU shares. Active virtual machines benefit when extra resources are available. In this example, virtual machine A gets four times as much CPU time as virtual machine B, subject to the specified CPU percentages. (By default the setting for **high** shares is four times that for **low** shares.)

That is, virtual machine A has four times as much CPU time as machine B, as long as the virtual machine A's CPU percentage is between 20% and 50%. In actuality, virtual machine A may only get twice the CPU time of virtual machine B, because four times the CPU time exceeds 50%, or the maximum CPU percentage of virtual machine A.

Using Hyper-Threading

Enabling Hyper-Threading in ESX Server

You should enable Hyper-Threading with the **Enable Hyper-Threading** option for your system startup profile. You can set this option with **Options->Startup Profile** in the Management Interface. See Updating the Startup Profile on page 218.

You can also enable Hyper-Threading in the Service Console. Edit the system profile `/etc/vmware/hwconfig` to set the `hyperthreading` option:

1. Log into the Service Console as `root`.
2. Edit `/etc/vmware/hwconfig`.
3. Define the `hyperthreading` option:

   ```
   hyperthreading = "true"
   ```

   If you previously defined this option, just change the current value to `true`.
4. Save the file and close it.

Configuring Hyper-Threading Options for Virtual Machines

You can configure the `htsharing` option with the **Verbose Options** configuration panel. Use the complete name of the option: `cpu.htsharing`. See Modifying the Configuration File Directly (Advanced Users Only) on page 141 for detailed instructions.

You can also configure `htsharing` in the Service Console, either by editing the virtual machine configuration file or by using the `procfs` command. see Editing the Virtual Machine Configuration File on page 395 or Using procfs on page 397.

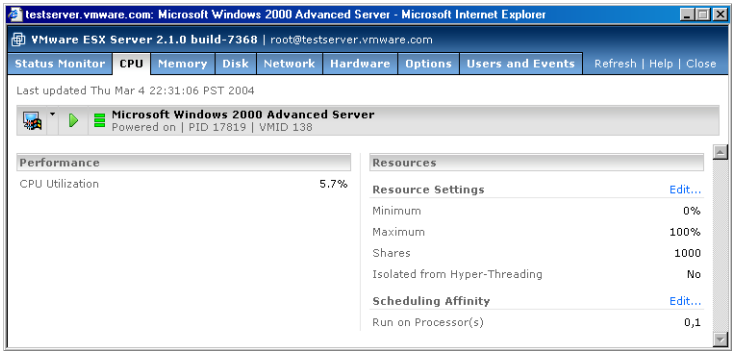
Managing Virtual Machine CPU Resources

You can manage CPU resources from the VMware Management Interface or from the service console.

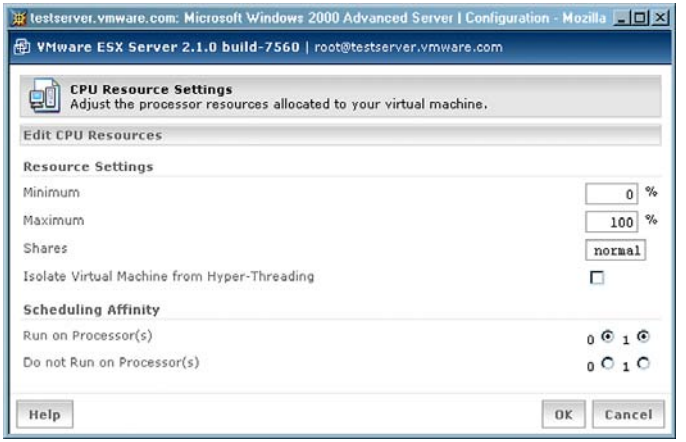
Managing CPU Resources from the Management Interface

You may also view and change settings from the virtual machine details pages in the VMware Management Interface.

1. On the server's Status Monitor page, click the name of an individual virtual machine. The details page for that virtual machine appears.
2. Click the **CPU** tab.



3. Click **Edit**. The CPU Resource Settings page appears.



4. Enter the desired settings, then click **OK**.

You must log in as root in order to change resource management settings using either the management interface or `procfs`.

Managing CPU Resources from the Service Console

You can also manage CPU resources by editing the virtual machine configuration (`.vmx`) file or using `procfs`.

Editing the Virtual Machine Configuration File

The following configuration options enable you to manage CPU resources.

`sched.cpu.shares = <n>`

This configuration file option specifies the initial share allocation for a virtual machine to `<n>` shares. The valid range of numerical values for `<n>` is `1` to `100000`. You may also use the special values **low**, **normal** and **high**. These values are automatically converted into numbers, through the configuration options `CpuSharesPerVcpuLow`, `CpuSharesPerVcpuNormal` and `CpuSharesPerVcpuHigh`, described in the next section, Using procfs on page 397.

If the number of CPU shares is not specified, the default allocation is **normal**, that by default, is set to `1000` shares per virtual CPU. The default allocation for a uniprocessor virtual machine is `1000` shares, or `2000` shares for a dual-virtual CPU (SMP) virtual machine.

`sched.cpu.min = <min>`
This configuration file option specifies a minimum CPU reservation `<min>`, as a percentage, for a virtual machine. The valid range of values for `<minPercent>` is `0` (the default minimum) to the number representing the total physical CPU resources. Note that the minimum may be greater than 100 for SMP virtual machines that are guaranteed more than one full physical CPU.

Note: If ESX Server is unable to guarantee a virtual machine's specified minimum percentage(s), you cannot power on that virtual machine. For example, if you have two uniprocessor (UP) virtual machines, each has a CPU minimum of 80%, and both are bound to the same processor, then ESX Server does not allow you to power on both virtual machines. The total CPU percentage is 160%, greater than a single processor.

`sched.cpu.max = <max>`
This configuration file option specifies a maximum CPU percentage `<maxPercent>` for a virtual machine. The valid range of values for `<maxPercent>` is `0` to the number representing the total physical CPU resources. Note that the maximum may be greater than 100 for SMP virtual machines that are guaranteed more than one full physical CPU. The default maximum is 100 times the number of virtual CPUs in the virtual machine; 100 percent for uniprocessor virtual machines and 200 percent for dual-virtual CPU virtual machines.

Note: A virtual machine will never use more CPU time than the specified maximum percentage.

`sched.cpu.affinity = <set>`
This configuration file option specifies the initial processor affinity set for a virtual machine. If `<set>` is `all` or `default`, then the affinity set contains all available processors. The specified set may also be a comma-separated list of CPU numbers such as `0,2,3`.

Note: For SMP virtual machines, the affinity set applies to all virtual CPUs on the virtual machine.

`cpu.htsharing = <mode>`
Setting the `htSharing` option configures the Hyper-Threading operation mode for the virtual machine identified by `<id>`. Valid modes are:

- `any` — Each CPU of the virtual machine can share the server's logical CPUs with all other virtual machines. This is the default value for `htSharing`.
- `none` — Each CPU of the virtual machine requires an entire physical CPU (two logical CPUs) of the server to operate. This prevents the virtual machine from

operating with the shared system resources provided by Hyper-Threading, and can reduce performance.

- `internal` — Each CPU of the virtual machine can share logical CPUs with the second CPU in the same virtual machine, but not with CPUs from other virtual machines. This mode switches to `none` for virtual machines with one CPU.

Note: Only SMP virtual machines can use multiple virtual CPUs.

Using procfs

You can also use `procfs` to manage CPU resources. Use the following command:

```
echo <new_value> > <proc_filename>
```

in the service console, where `<new_value>` is the value you wish to set and `<proc_filename>` is the full path name of the configuration option's `proc` entry. See Examples on page 399 for additional information.

Note: For SMP virtual machines, you can use the `<id>` of any of the virtual CPUs to view or change configuration options for that virtual machine.

`/proc/vmware/vm/<id>/cpu/min`

Reading from this file reports the minimum CPU percentage allocated to the virtual machine identified by `<id>`.

Specifying a percentage `<minPercent>`, to this file changes the minimum percentage allocated to the virtual machine identified by `<id>` to `<minPercent>`. The valid range of values for `<minPercent>` is `0` to 100 multiplied by the number of virtual CPUs; that is, 100 percent for uniprocessor virtual machines, and 200 percent for dual-virtual CPU virtual machines.

Note: If there is not enough unreserved CPU time available in the system to satisfy a demand for an increase in `min`, then the reservation will not be changed.

`/proc/vmware/vm/<id>/cpu/max`

Reading from this file reports the maximum CPU percentage allocated to the virtual machine identified by `<id>`.

Specifying a percentage `<maxPercent>`, to this file changes the maximum percentage allocated to the virtual machine identified by `<id>` to `<maxPercent>`. The valid range of values for `<maxPercent>` is `0` to 100 multiplied by the number of virtual CPUs, or 100 percent for uniprocessor virtual machines, and 200 percent for dual-virtual CPU virtual machines.

`/proc/vmware/vm/<id>/cpu/shares`

Reading from this file reports the number of shares allocated to the virtual machine identified by `<id>`.

Writing a number <n> to this file changes the number of shares allocated to the virtual machine identified by <id> to <n>. The valid range of numerical values for <n> is 1 to 100000. Or, you may use the special values **low**, **normal** and **high**. These values are automatically converted into numbers, through the configuration options CpuSharesPerVcpuLow, CpuSharesPerVcpuNormal and CpuSharesPerVcpuHigh, described in this section.

/proc/vmware/vm/<id>/cpu/affinity
Reading from this file reports the number of each CPU in the current affinity set for the virtual machine identified by <id>.

Writing a comma-separated list of CPU numbers to this file, such as 0,2,3, changes the affinity set for the virtual machine identified by <id>. Writing all or default to this file changes the affinity set to contain all available processors.

For SMP virtual machines, writing to this file changes the affinity of all virtual CPUs in the virtual machine to the specified affinity set.

/proc/vmware/vm/<id>/cpu/hyperthreading
Reading from this file reports the Hyper-Threading state of the virtual machine identified by <id>.

Setting the htSharing option configures the Hyper-Threading operation mode for the virtual machine identified by <id>. Valid modes are:

- any — Each CPU of the virtual machine can share the server's logical CPUs with all other virtual machines. This is the default value for htSharing.
- none — Each CPU of the virtual machine requires an entire physical CPU (two logical CPUs) of the server to operate. This prevents the virtual machine from operating with the shared system resources provided by Hyper-Threading, and can reduce performance.
- internal — Each CPU of the virtual machine can share logical CPUs with the second CPU in the same virtual machine, but not with CPUs from other virtual machines. This mode switches to none for virtual machines with one CPU.

Note: Only SMP virtual machines can use multiple virtual CPUs.

/proc/vmware/vm/<vcpuid>/cpu/status
Reading from this file reports current status information for the virtual CPU identified by <vcpuid>, including the specified shares and affinity parameters, as well as the virtual machine name, state (running, ready, waiting), current CPU assignment and cumulative CPU usage in seconds.

`/proc/vmware/sched/cpu`
Reading from this file reports the status information for all virtual machines in the entire system. Each virtual CPU is displayed on its own line, with information including uptime, time used, and resource management parameters.

`/proc/vmware/config/CpuSharesPerVcpuLow`
This option specifies the a numerical value for the **low** value. By default, this number is `500`. Since this value is expressed in shares per virtual CPU, the allocation for a uniprocessor virtual machine is `500` shares, or `1000` shares for a dual-virtual CPU (SMP) virtual machine.

`/proc/vmware/config/CpuSharesPerVcpuNormal`
This option specifies the a numerical value for the **normal** value. By default, this number is `1000`. For a uniprocessor virtual machine, the default allocation is `1000` shares, or `2000` shares for a dual-virtual CPU (SMP) virtual machine.

`/proc/vmware/config/CpuSharesPerVcpuHigh`
This option specifies the a numerical value for the **high** value. By default, this number is `2000`. For a uniprocessor virtual machine, the default allocation is `2000` shares, or `4000` shares for a dual-virtual CPU (SMP) virtual machine.

Examples
Suppose that we are interested in the CPU allocation for the virtual machine with ID 103. To query the number of shares allocated to virtual machine 103, simply read the file.

```
cat /proc/vmware/vm/103/cpu/shares
```

The number of shares is displayed.

```
1000
```

This indicates that virtual machine 103 is currently allocated 1,000 shares. To change the number of shares allocated to virtual machine 103, simply write to the file. Note that you need root privileges in order to change share allocations.

```
echo 2000 > /proc/vmware/vm/103/cpu/shares
```

You can also write to the file by specifying **low**, **normal**, or **high**. ESX Server writes the numerical value for these special values.

```
echo high > /proc/vmware/vm/103/cpu/shares
```

The change can be confirmed by reading the file again.

```
cat /proc/vmware/vm/103/cpu/shares
```

The number of shares is displayed.

```
2000
```

To query the affinity set for virtual machine 103, simply read the file:

```
cat /proc/vmware/vm/103/cpu/affinity
```

The identifying numbers of the processors in the affinity set are displayed.

```
0,1
```

This indicates that virtual machine 103 is allowed to run on CPUs 0 and 1. To restrict virtual machine 103 to run only on CPU 1, simply write to the file. Note that you need root privileges in order to change affinity sets.

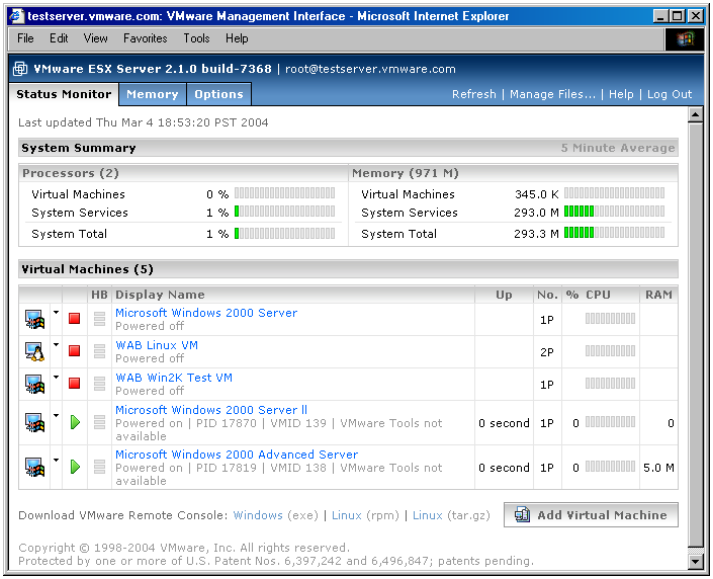
```
echo 1 > /proc/vmware/vm/103/cpu/affinity
```

The change can be confirmed by reading the file again.

Note: The affinity set must contain at least as many CPUs as virtual CPUs; that is, 1 CPU for a uniprocessor (UP) virtual machine, and 2 CPU for a SMP virtual machine.

Monitoring CPU Statistics

The VMware Management Interface provides information on the current use of CPU by the physical computer and the virtual machines running on it. View the Status Monitor page in the management interface.



The System Summary section at the top shows systemwide information. The Virtual Machines section below it shows information for particular virtual machines.

You can also read the current CPU statistics for a virtual machine from its status file on the service console. For example, to view the statistics for the virtual machine with ID 137, use this command:

```
cat /proc/vmware/vm/137/cpu/status
```

The results are displayed in the following format:

```
vcpu  vm   name          uptime   status  costatus  usedsec  syssec
137   137  vmm0:Win2kAS  357.866  RUN     RUN       265.143  3.105

wait  waitsec  cpu   affinity  min   max   shares  emin  extrasec
NONE  51.783   0     0,1       0     200   2000    72    124.758
```

The output above is shown with additional line breaks, in order to avoid wrapping long lines. All times are reported in seconds, with millisecond resolution. Min and max percentages are reported as a percentage of a single processor.

The columns indicate:

`vcpu`	Virtual CPU identifier
`vm`	Virtual machine identifier
`name`	Display name associated with the virtual machine
`uptime`	Elapsed time since the virtual machine was powered on
`status`	Current VCPU run state: running (**`RUN`**), ready to run (**`READY`**), waiting on an event (**`WAIT`** or **`WAITB`**), terminating (**`ZOMBIE`**). There are additional states for SMP virtual machines: ready with pending co-schedule (**`CORUN`**), ready but co-descheduled (**`COSTOP`**).
`costatus`	Current SMP virtual machine co-scheduling state: uniprocessor virtual machine (**`NONE`**), ready to run (**`READY`**), co-scheduled (**`RUN`**), co-descheduled (**`STOP`**).
`usedsec`	Cumulative processor time consumed by the VCPU.
`syssec`	Cumulative system time consumed by the VCPU.
`wait`	Current VCPU wait event type: not waiting (**`NONE`**), idle (**`IDLE`**), file system (**`FS`**), swap (**`SWPA`**, **`SWPS`**), remote procedure call (**`RPC`**), waiting for request (**`RQ`**), and so on.
`waitsec`	Cumulative VCPU wait time.
`cpu`	Current VCPU processor assignment.
`affinity`	Processor affinity for VCPU.
`min`	Minimum processor percentage reservation for the virtual machine.
`max`	Maximum processor percentage allowed for the virtual machine.

`shares`	CPU shares allocation for the virtual machine.
`emin`	Effective minimum percentage allocation for the virtual machine.
`extrasec`	Cumulative processor consumption above `emin` by the virtual machine.

In this example, ID 137 is an SMP virtual machine with two virtual CPUs. The output shows statistics associated with its first virtual cpu `vmm0`, identified as vcpu 137, with a configured display name that begins with "Win2kAS". The virtual CPU is currently running on processor 0, and is currently co-scheduled with the second VCPU associated with this virtual machine. The VCPU has been up for about 358 seconds, during which time it has consumed about 265 seconds of processor time, including about 3 seconds of ESX Server system time (such as processing interrupts on behalf of the virtual machine).

The virtual CPU is not currently waiting, but has waited for a total of about 52 seconds since it has powered on. Together, both of the virtual machine's virtual CPUs are allowed to use between 0 and 2 physical processors (`min`=0% and `max`=200%). The virtual machine's allocation of 2000 shares currently entitles it to consume processor time equivalent to 72% of a single processor. Since powering on, the virtual machine has received about 124 seconds of CPU time above its entitlement, by consuming "extra" time leftover from other virtual machines that did not fully utilize their allocations.

Memory Resource Management

VMware ESX Server provides dynamic control over the amount of physical memory allocated to each virtual machine. You may overcommit memory, if you wish, so the total size configured for all running virtual machines exceeds the total amount of available physical memory. The system manages the allocation of memory to virtual machines automatically based on allocation parameters and system load.

You may specify initial memory allocation values for a virtual machine in its configuration file. You may also modify most memory allocation parameters dynamically using the VMware Management Interface, the `procfs` interface on the service console or the VMware Scripting API. Reasonable defaults are used automatically when parameters are not specified explicitly.

You have access to information about current memory allocations and other status information through the management interface, the `procfs` interface on the service console and the VMware Scripting API.

For additional information on memory management by VMware ESX Server, see the `mem(8)` man page. You may also view the abstract of a technical paper describing memory resource management at *www.usenix.org/events/osdi02/tech/waldspurger.html*.

If you have a server with NUMA architecture, be sure to see Using Your NUMA System on page 418. Refer to the VMware ESX Server2 NUMA Support White Paper, available at *www.vmware.com/pdf/esx2_NUMA.pdf* for information on supported NUMA platforms.

Allocating Memory Resources

Three basic parameters control the allocation of memory resources to each virtual machine:

- Its minimum size — min

  The minimum size is a guaranteed lower bound on the amount of memory that is allocated to the virtual machine, even when memory is overcommitted. The system uses an admission control policy to enforce this guarantee. You cannot power on a new virtual machine if there isn't sufficient memory to reserve its minimum size.

  Set a virtual machine's minimum for the minimal acceptable performance and above the threshold where the guest operating system begins swapping heavily. Use the performance monitoring tool of the guest operating system to see if you are swapping. For more information on improving guest operating

system performance, see Improving Slow Performance on Virtual Machines on page 387.

- Its maximum size — max

  The maximum size is the amount of memory configured for use by the guest operating system running in the virtual machine. This maximum size must be specified in the configuration file for the virtual machine. By default, virtual machines operate at their maximum allocation, unless memory is overcommitted.

  Note: You must specify a maximum memory size for a guest operating system, or it will not boot. Also, you can only change a virtual machine's maximum memory size when it is powered off.

- Its share allocation

  Memory shares entitle a virtual machine to a fraction of physical memory. For example, a virtual machine that has twice as many shares as another is generally entitled to consume twice as much memory, subject to their respective minimum and maximum constraints, provided they are both actively using the memory they have been allocated.

  You may specify shares by specifying a numerical value, or specifying **high**, **normal**, or **low**. By default, the setting for **normal** shares is twice that of **low**. Similarly, **high** shares are twice that of **normal** (or four times that of **low**).

The system automatically allocates an amount of memory to each virtual machine somewhere between its minimum and maximum sizes based on its shares and an estimate of its recent working set size.

Setting Memory Minimum, Maximum, and Shares

You can set a memory minimum, memory maximum, and shares to manage memory resources for your virtual machines. Memory minimums and maximums specify absolutes, an absolute minimum or maximum memory usage by a virtual machine. Shares, on the other hand, represent relative importance or priority. You set shares to specify which virtual machines will get preferential treatment when ESX Server is overcommitted.

For example, virtual machine A has a minimum memory size of 192MB, and a maximum memory size of 256MB, while virtual machine B has a minimum memory size of 256MB and a maximum memory size of 512MB.

You then decide to give virtual machine A **high** memory shares and virtual machine B **normal** memory shares. By default, the setting for **high** is twice that of **normal**, or four

times that of **low**. For example, a virtual machine with **high** shares has twice as many shares as a virtual machine with **normal** shares, or four times as many shares as a virtual machine with **low** shares. If you want to change these defaults, see Service Console Commands on page 412.

ESX Server interprets this allocation so that virtual machine A will never have less than 192MB memory, while virtual machine B will never have less than 256MB memory, in any situation.

However, if one or more virtual machines are not actively using their allocated memory (for example, the virtual machines are idling), then ESX Server may redistribute a portion of this unused memory proportionally, based on the virtual machines' memory shares. Active virtual machines benefit when extra resources are available. In this example, because virtual machine A has **high** shares, it can get twice as much memory as virtual machine B (**low** shares), subject to the specified memory minimum or maximum.

For detailed information on how ESX Server dynamically redistributes memory, see Allocating Memory Dynamically on page 406.

Admission Control Policy

VMware ESX Server uses an admission control policy to ensure that sufficient unreserved memory and swap space are available before powering on a virtual machine. Memory must be reserved for the virtual machine's guaranteed minimum size; additional overhead memory is required for virtualization. Thus the total required for each virtual machine is the specified minimum plus overhead.

The overhead memory size is determined automatically; it is typically 54MB for a single virtual CPU virtual machine, and 64MB for a dual-virtual CPU SMP virtual machine. Additional overhead memory is reserved for virtual machines larger than 512MB.

Note: To create SMP virtual machines with ESX Server, you must also have purchased the VMware Virtual SMP for ESX Server product. For more information on the VMware Virtual SMP for ESX Server product, contact VMware, Inc. or your authorized sales representative.

Swap space must be reserved on disk for the remaining virtual machine memory — that is the difference between the maximum and minimum settings. This swap reservation is required to ensure the system is able to preserve virtual machine memory under any circumstances. In practice, only a small fraction of the swap space may actually be used.

Similarly, while memory reservations are used for admission control, actual memory allocations vary dynamically, and unused reservations are not wasted.

The amount of swap space configured for the system limits the maximum level of overcommitment. A default swap file size equal to the physical memory size of the computer is recommended in order to support a reasonable 2x level of memory overcommitment. You may configure larger or smaller swap files or add additional swap files.

If you do not configure a swap file, memory may not be overcommitted. You may configure the swap file using the VMware Management Interface (**Swap Configuration** in the **Options** page) or from the service console using the `vmkfstools` command.

You can create additional swap files using the vmkfstools command. You should consider adding additional swap files if you want to run additional virtual machines but you're unable to do so because of the lack of swap space. See Using vmkfstools on page 259.

Allocating Memory Dynamically

Virtual machines are allocated their maximum memory size unless memory is overcommitted. When memory is overcommitted, each virtual machine is allocated an amount of memory somewhere between its minimum and maximum sizes. The amount of memory granted to a virtual machine above its minimum size may vary with the current memory load. The system automatically determines allocations for each virtual machine based on two factors: the number of shares it has been given and an estimate of its recent working set size.

ESX Server uses a modified proportional-share memory allocation policy. Memory shares entitle a virtual machine to a fraction of physical memory. For example, a virtual machine that has twice as many shares as another is entitled to consume twice as much memory, subject to their respective minimum and maximum constraints, provided that they are both actively using the memory they have been allocated. In general, a virtual machine with *S* memory shares in a system with an overall total of *T* shares is entitled to receive at least a fraction *S/T* of physical memory.

However, virtual machines that are not actively using their currently allocated memory automatically have their effective number of shares reduced, by levying a tax on idle memory. This "memory tax" helps prevent virtual machines from unproductively hoarding idle memory. A virtual machine is charged more for an idle page than for a page that it is actively using.

The `MemIdleTax` configuration option provides explicit control over the policy for reclaiming idle memory. You may use this option, together with the `MemSamplePeriod` configuration option, to control how the system reclaims memory. However, in most cases, changes shouldn't be necessary. For complete information on using these options, see Service Console Commands on page 412.

ESX Server estimates the working set for a virtual machine automatically by monitoring memory activity over successive periods of virtual machine virtual time. Estimates are smoothed over several time periods using techniques that respond rapidly to increases in working set size and more slowly to decreases in working set size. This approach ensures that a virtual machine from which idle memory has been reclaimed is be able to ramp up quickly to its full share-based allocation once it starts using its memory more actively. You can modify the default monitoring period of 30 seconds by adjusting the `MemSamplePeriod` configuration option.

Reclaiming Memory from Virtual Machines

ESX Server employs two distinct techniques for dynamically expanding or contracting the amount of memory allocated to virtual machines — a VMware-supplied `vmmemctl` module that is loaded into the guest operating system running in a virtual machine, and swapping pages from a virtual machine to a server swap file without any involvement by the guest operating system.

The preferred mechanism is the `vmmemctl` driver, which cooperates with the server to reclaim those pages that are considered least valuable by the guest operating system. The `vmmemctl` driver uses a proprietary "ballooning" technique, that provides predictable performance which closely matches the behavior of a native system under similar memory constraints. It effectively increases or decreases memory pressure on the guest operating system, causing the guest to invoke its own native memory management algorithms. When memory is tight, the guest operating system decides which particular pages to reclaim and, if necessary, swaps them to its own virtual disk. The guest operating system must be configured with sufficient swap space. Some guest operating systems have additional limitations. See the notes in Managing Memory Resources from the Service Console on page 411 for details. If necessary, you can limit the amount of memory reclaimed using `vmmemctl` by setting the `sched.mem.maxmemctl` option. This option specifies the maximum amount of memory that may be reclaimed from a virtual machine in megabytes (MB).

Swapping is used to forcibly reclaim memory from a virtual machine when no `vmmemctl` driver is available. This may be the case if the `vmmemctl` driver was never installed, has been explicitly disabled, is not running (for example, while the guest operating system is booting) or is temporarily unable to reclaim memory

quickly enough to satisfy current system demands. Standard demand paging techniques swap pages back in when the virtual machine needs them.

The `vmmemctl` approach is used whenever possible for optimum performance. swapping is a reliable mechanism of last resort that the system uses to reclaim memory only when necessary.

Swap Space and Guest Operating Systems

If you choose to overcommit memory with ESX Server, then you need to be sure your guest operating systems have sufficient swap space. This swap space must be greater than or equal to the difference between the virtual machine's maximum and minimum sizes.

Caution: If memory is overcommitted, and the guest operating system is configured with insufficient swap space, the guest operating system in the virtual machine may fail.

To prevent virtual machine failure, increase the swap size in your virtual machines:

- Windows guest operating systems — Windows operating systems refer to their swap space as "paging files." Some Windows operating systems automatically try to increase the size of paging files, provided there is sufficient free disk space.

  For more information, refer to your Windows documentation or search the Windows help files for "paging files." Follow the instructions for changing the size of the virtual memory paging file.

- Linux guest operating system — Linux operating systems refer to their swap space as "swap files." For information on increasing swap files, refer to the `mkswap` (sets up a Linux swap area) and `swapon` (enables devices and files for paging and swapping) man pages found in your Linux guest operating system.

Guest operating systems with large memory and small virtual disks (for example, a virtual machine with 3.6GB RAM and a 2 GB virtual disk) are more susceptible to this problem.

Sharing Memory Across Virtual Machines

Many ESX Server workloads present opportunities for sharing memory across virtual machines. For example, several virtual machines may be running instances of the same guest operating system, have the same applications or components loaded, or contain common data. In such cases, ESX Server uses a proprietary transparent page sharing technique to securely eliminate redundant copies of memory pages. With memory sharing, a workload running in virtual machines often consumes less

memory than it would when running on physical machines. As a result, higher levels of overcommitment can be supported efficiently.

The ESX Server approach does not require any cooperation from the guest operating system. You may use the `MemShareScanVM` and `MemShareScanTotal` configuration options to control the rate at which the system scans memory to identify opportunities for sharing memory. For more information on these options, see Service Console Commands on page 412.

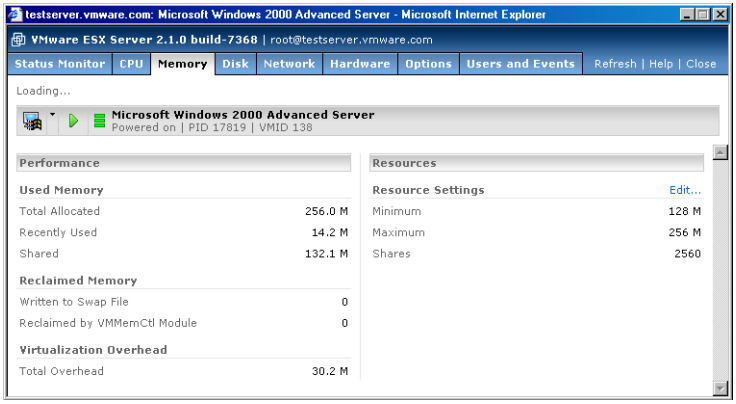
Managing Virtual Machine Memory

You can manage virtual machine memory from the VMware Management Interface or from the service console.

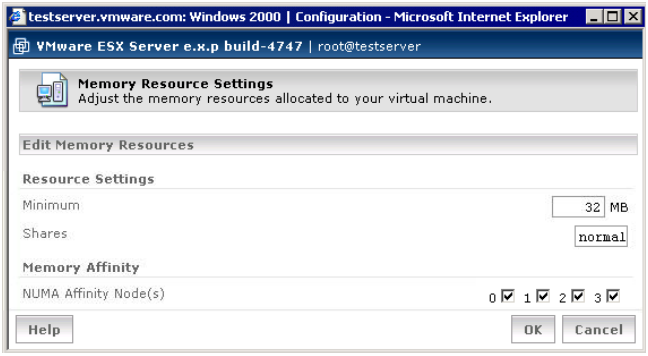
Managing Memory Resources from the Management Interface

You may also view and change settings from the virtual machine details pages in the VMware Management Interface.

1. On the server's Status Monitor page, click the name of an individual virtual machine. The details page for that virtual machine appears.
2. Click the **Memory** tab.



3. Click **Edit**. The Memory Resource Settings page appears.



4. Enter the desired settings, then click **OK**.

You must log in as root in order to change resource management settings using either the management interface or `procfs`.

Managing Memory Resources from the Service Console

You can also manage memory resources by editing the following settings in the virtual machine's configuration file. To edit the configuration file, use the configuration file editor in the management interface. See Editing a Virtual Machine's Configuration File Directly on page 144 for details.

`memsize = <size>`
This configuration file option specifies the maximum virtual machine size to be `<size>`MB.

`sched.mem.minsize = <size>`
This configuration file option specifies the guaranteed minimum virtual machine size to be `<size>`MB. The maximum valid value for `<size>` is 100 percent of the specified maximum virtual machine size. The minimum valid value for `<size>` depends on the amount of available swap space. The default minimum size is 50 percent of the specified maximum virtual machine size.

`sched.mem.shares = <n>`
This configuration file option specifies the initial memory share allocation for a virtual machine to be `<n>` shares. The valid range of numerical values for `<n>` is `0` to `100000`. You may also use the special values **low**, **normal** and **high**. These values are automatically converted into numbers, through the configuration options `MemSharesPerMBLow`, `MemSharesPerMBNormal` and `MemSharesPerMBHigh`, described in the next section. If the number of shares for a virtual machine is not specified, the assigned allocation is **normal**, with a default value equal to 10 times the virtual machine's maximum memory, in MB.

For example, if you created a virtual machine with a maximum memory of 256MB, and with its shares settings as **normal**, then this virtual machine has 10 times 256, or `2560` shares. Similarly, a virtual machine with a maximum memory of 1GB with a **normal** share setting, has `10240` shares.

`sched.mem.maxmemctl = <size>`
This configuration file option specifies the maximum amount of memory that may be reclaimed from the virtual machine using `vmmemctl` to be `<size>`MB. If additional memory needs to be reclaimed, the system swaps instead of using `vmmemctl`. The default maximum size is half of the specified maximum virtual machine size.

`sched.mem.affinity = <NUMA_node>`
This configuration file option specifies that, if possible, all of the virtual machine's

memory should be allocated on the specified NUMA node. For more information, see Associating Future Virtual Machine Memory Allocations with a NUMA Node on page 422.

Service Console Commands

`/proc/vmware/vm/<id>/mem/min`
Reading from this file reports the minimum memory size in megabytes for the virtual machine identified by `<id>`.

Writing a number `<size>` to this file changes the minimum memory size for the virtual machine identified by `<id>` to `<size>`MB.

`/proc/vmware/vm/<id>/mem/shares`
Reading from this file reports the number of memory shares allocated to the virtual machine identified by `<id>`.

Writing a number `<n>` to this file changes the number of memory shares allocated to the virtual machine identified by `<id>` to `<n>`. The valid range of numerical values for `<n>` is `0` to `100000`. You may also use the special values **low**, **normal** and **high**. These values are automatically converted into numbers, through the configuration options `MemSharesPerMBLow`, `MemSharesPerMBNormal` and `MemSharesPerMBHigh`, described below.

Note that a value of zero (`0`) shares causes the virtual machine memory size allocation to be exactly equal to its specified minimum size, even if excess memory is available.

`/proc/vmware/vm/<id>/mem/status`
Reading from this file reports current status information for the virtual machine identified by `<id>`, including the specified shares, minimum size and maximum size parameters as well as the virtual machine name, current status, whether the virtual machine is currently waiting for memory to be reserved, current memory usage, current target size, memory overhead for virtualization and the amount of allocated memory actively in use. All memory sizes are reported in kilobytes.

`/proc/vmware/sched/mem`
Reading from this file reports the memory status information for all non-system virtual machines in the entire system as well as several aggregate totals.

Writing the string `realloc` to this file causes an immediate memory reallocation. Memory is normally reallocated periodically every `MemBalancePeriod` seconds. (See `/proc/vmware/config/MemBalancePeriod` below for more information.) Reallocations are also triggered by significant changes in the amount of free memory.

`/proc/vmware/mem`
Reading from this file reports the maximum size with which a new virtual machine can be powered on, admission control status including the amount of unreserved memory and unreserved swap space and the current amount of free memory in the system.

`/proc/vmware/pshare/status`
Reading from this file reports various detailed statistics about the current status of transparent page sharing.

`/proc/vmware/swap/stats`
Reading from this file reports various detailed swap statistics.

`/proc/vmware/config/MemSharesPerMBLow`
This option specifies the a numerical value for the **low** shares value. By default, this number is `5`.This number is multiplied by the virtual machine's maximum memory size to obtain the number of shares.

`/proc/vmware/config/MemSharesPerMBNormal`
This option specifies the a numerical value for the **normal** shares value. By default, this number is `10`. This number is multiplied by the virtual machine's maximum memory size to obtain the number of shares.

`/proc/vmware/config/MemSharesPerMBHigh`
This option specifies the a numerical value for the **high** shares value. By default, this number is `20`. This number is multiplied by the virtual machine's maximum memory size to obtain the number of shares.

`/proc/vmware/config/MemBalancePeriod`
This ESX Server option specifies the periodic time interval, in seconds, for automatic memory reallocations. Reallocations are also triggered by significant changes in the amount of free memory. The default is 15 seconds.

`/proc/vmware/config/MemSamplePeriod`
This ESX Server option specifies the periodic time interval, measured in seconds of virtual machine virtual time, over which memory activity is monitored in order to estimate working set sizes. The default is 30 seconds.

`/proc/vmware/config/MemIdleTax`
This ESX Server option specifies the idle memory tax rate as a percentage. A tax rate of *x* percent means that up to *x* percent of a virtual machine's idle memory may be reclaimed. Virtual machines are charged more for idle memory, than for memory that they are actively using. A tax rate of 0 percent defines an allocation policy that ignores working sets and allocates memory strictly based on shares. A high tax rate results in

an allocation policy that allows idle memory to be reallocated away from virtual machines that are unproductively hoarding it, regardless of shares. The default is 75 percent.

`/proc/vmware/config/MemShareScanVM`
This ESX Server option specifies the maximum per-virtual machine rate at which memory should be scanned for transparent page sharing opportunities. The rate is specified as the number of pages to scan per second. The default is 50 pages per second per virtual machine.

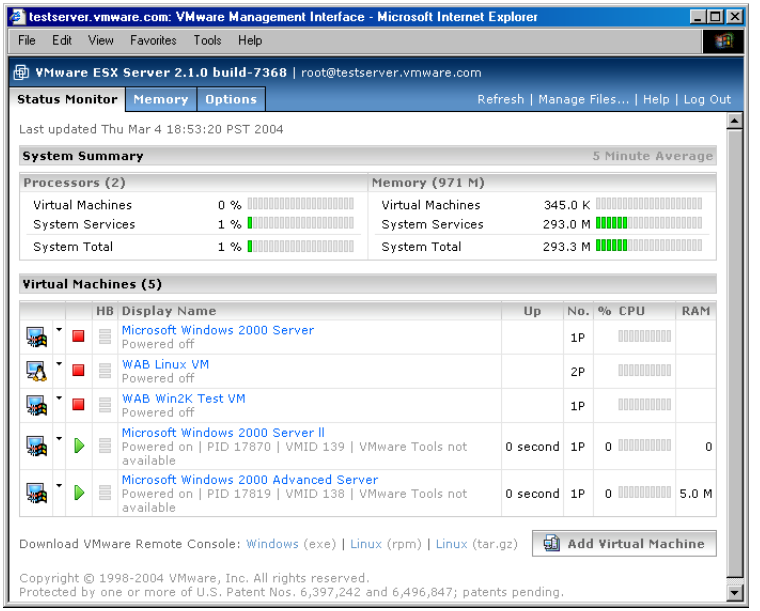
`/proc/vmware/config/MemShareScanTotal`
This ESX Server option specifies the total systemwide rate at which memory should be scanned for transparent page sharing opportunities. The rate is specified as the number of pages to scan per second. The default is 200 pages per second.

`/proc/vmware/config/MemCtlMaxPercent`
This ESX Server option limits the maximum amount of memory that may be reclaimed from any virtual machine using `vmmemctl`, based on a percentage of its maximum size. Specifying 0 effectively disables reclamation via `vmmemctl` for all virtual machines. Defaults to 50.

`/proc/vmware/config/MemCtlMax[OSType]`
These ESX Server options restrict the maximum amount of memory that may be reclaimed from a virtual machine using `vmmemctl`, based on the limitations of guest operating system type. The value is specified in megabytes. Defaults to 128 for `OSType=NT4` (Windows NT 4.0), 2048 for `OSType=NT5` (Windows 2000 or Windows Server 2003), and 768 for `OSType=Linux`.

Monitoring Memory Statistics

The VMware Management Interface provides information on the current use of RAM by the physical computer and the virtual machines running on it. View the Status Monitor page in the management interface.


testserver.vmware.com: VMware Management Interface - Microsoft Internet Explorer
File Edit View Favorites Tools Help
VMware ESX Server 2.1.0 build-7368 | root@testserver.vmware.com
Status Monitor
Memory
Options
Refresh | Manage Files... | Help | Log Out
Last updated Thu Mar 4 18:53:20 PST 2004
System Summary
5 Minute Average
Processors (2)
Virtual Machines 0 %
System Services 1 %
System Total 1 %
Memory (971 M)
Virtual Machines 345.0 K
System Services 293.0 M
System Total 293.3 M
Virtual Machines (5)
HB Display Name Up No. % CPU RAM
Microsoft Windows 2000 Server
Powered off
1P
WAB Linux VM
Powered off
2P
WAB Win2K Test VM
Powered off
1P
Microsoft Windows 2000 Server II
Powered on | PID 17870 | VMID 139 | VMware Tools not available
0 second 1P 0 0
Microsoft Windows 2000 Advanced Server
Powered on | PID 17819 | VMID 138 | VMware Tools not available
0 second 1P 0 5.0 M
Download VMware Remote Console: Windows (exe) | Linux (rpm) | Linux (tar.gz)
Add Virtual Machine
Copyright © 1998-2004 VMware, Inc. All rights reserved.
Protected by one or more of U.S. Patent Nos. 6,397,242 and 6,496,847; patents pending.

The System Summary section at the top shows systemwide information. The Virtual Machines section below it shows information for particular virtual machines.

You can also read the current memory statistics for a virtual machine from its status file on the service console. For example, to view the statistics for the virtual machine with ID 103, use this command:

```
cat /proc/vmware/vm/103/mem/status
```

The results are displayed in the following format:

```
vm      mctl?     shares  min      max      size/sizetgt
103     yes       2560    131072   262144   217300/217300

memctl/mctltgt   swapped/swaptgt  swapin   swapout
39168/ 39168     5672/   5672     13289    18961

cptread/cpt-tgt  shared  active   overhd/ovhdmax   ovhdpeak  affinity
```

```
0/     0         38164   191756   14508/  55296     14508    0
```

The preceding output is shown with additional line breaks, in order to avoid wrapping long lines. All memory sizes are reported in kilobytes; 1 megabyte = 1024KB. The columns indicate:

`vm`	Virtual machine identifier
`mctl?`	`vmmemctl` driver active?
`shares`	Memory shares associated with the virtual machine
`min`	Minimum size
`max`	Maximum size
`size`	Current size
`sizetgt`	Target size
`memctl`	Currently reclaimed using `vmmemctl`
`mctltgt`	Target to reclaim using `vmmemctl`
`swapped`	Currently swapped to VMFS swap file
`swaptgt`	Target to swap to VMFS swap file
`swapin`	Total number of pages swapped in from VMFS swap file
`swapout`	Total number of pages swapped out to VMFS swap file
`cptread`	(Resumed virtual machines only) Number of pages read from suspend file
`cpt-tgt`	(Resumed virtual machines only) Number of pages to read from suspend file
`shared`	Memory shared via transparent page sharing
`active`	Current working set estimate
`overhd`	Current overhead memory size
`ovhdmax`	Maximum overhead memory size
`ovhdpeak`	Maximum overhead memory used
`affinity`	(NUMA machines only) Memory affinity for the virtual machine

In this example, the virtual machine with ID 103 is running the `vmmemctl` driver and is not currently blocked waiting for memory. The virtual machine is configured to use between 128MB and 256MB and has been allocated 2560 memory shares. It is currently allocated about 212MB. Approximately 44MB has been reclaimed for use by other virtual machines — 38MB via `vmmemctl` and nearly 6MB via swapping to the ESX server swap file. Of the 212MB allocated to the virtual machine, more than 37MB is shared — for example with other virtual machines. The current working set estimate for the virtual machine is approximately 187MB. About 14MB of overhead memory is currently being used for virtualization, out of a maximum of 54MB.

Cautions

VMware supplies `vmmemctl` drivers for Windows Server 2003, Windows XP, Windows 2000, Windows NT 4.0, and Linux. The appropriate `vmmemctl` driver is installed

automatically when you install VMware Tools in the guest operating system. The system uses swapping to reclaim memory from virtual machines running other guest operating systems and from virtual machines that do not have VMware Tools installed.

The maximum amount of memory that the system may attempt to reclaim using `vmmemctl` is restricted automatically based on known limitations of the type of guest operating system. Alternatively, you may specify the configuration file option `sched.mem.maxmemctl` manually. See the description of the ESX Server options `MemCtlMax[OSType]` for appropriate limits.

Using Your NUMA System

ESX Server 2.1 includes additional support for machines that are based on NUMA (Non-Uniform Memory Access) architecture. NUMA machines are made up of multiple nodes (also called CECs on IBM eServer machines).

Each node comprises one to four processors and main memory. In a node, each CPU has the same distance from its "local memory."

Each processor can access memory on any node, but accessing memory on a different node (referred to as "remote memory") is substantially slower than accessing "local memory" that lies on the same node as the processor. That is, the memory access speed for CPUs on a node vary, depending on the "distance" of the memory from the node.

For additional information on NUMA and supported NUMA platforms, refer to the VMware ESX Server2 NUMA Support White Paper, available at *www.vmware.com/pdf/esx2_NUMA.pdf*.

For more information on NUMA management by VMware ESX Server, see the `numa(8)` man page.

NUMA Configuration Information

This section describes how to obtain statistics about your NUMA system.

Obtaining NUMA Statistics

This command checks for the presence of a NUMA system. If it finds a NUMA system, it also lists the number of nodes, the amount of memory, and the physical CPUs on the NUMA node.

Type the following:

```
cat /proc/vmware/NUMA/hardware
```

An example output is:

```
System type : IBM x445-compatible
# NUMA Nodes : 2
Total memory : 8192 MB
Node    ID        MachineMem    ManagedMem  CPUs
0       00        4096 MB       3257 MB     0 1 2 3
1       01        4096 MB       4096 MB     4 5 6 7
```

The absence of the `/proc/vmware/NUMA` directory indicates that this system is not a NUMA system.

The system type indicates the hardware for your NUMA system (in this case, an IBM x445 server). There are two NUMA nodes.

The fields in the table are defined as follows:

- Node — Node number
- ID — Hardware ID number of the NUMA node
- MachineMem — Amount of physical memory located on this NUMA node, including memory that may be used by the service console.
- ManagedMem — Amount of physical memory located on this NUMA node, excluding memory used by the service console and the ESX Server virtualization layer.
- CPUs — A space-separated list of the physical processors in this node.

  Physical CPUs 0, 1, 2, and 3 are in NUMA node 0, and physical CPUs 4, 5, 6, and 7 are in NUMA node 1.

Total memory tells you how much memory is physically installed on each NUMA node. However not all of this memory may be managed by the VMkernel, as some of the memory is used by the service console.

Determining the Amount of Memory for each NUMA Node

Type the following:

```
cat /proc/vmware/mem/
```

An example output is:

```
.
.
.
Node    Total-/MB       FreeHi/MB       FreeLow/MB   Reserved/MB   Kernel/MB
0       836022/3265     98304/384       737528/2880  34574/135     190/0
1       2621440/10240   2601144/10160   0/0          0/0           20296/79
Totals                  2699448/10544   737528/2880
```

In this preceding example, the total memory managed by the VMkernel for the NUMA nodes is listed in the `Totals` row. (This amount may be smaller than the total amount of physical memory on the server machine.

Determining the Amount of Memory for a Virtual Machine on a NUMA Node

Type the following:

```
cat /proc/vmware/vm/<id>/mem/numa
```

An example output is:

```
Node#      Pages/MB
0          13250/51
1          0/0
```

The preceding output indicates that the virtual machine, with the specified ID, occupies 51MB of memory on node 0, and no memory on node 1.

Note: In this preceding example, the memory affinity is set so that only pages associated with node 0 are allocated for this virtual machine (`sched.mem.affinity = 0`). If memory affinity had not been set, then typically the output would have shown a more even distribution of memory between nodes 0 and 1. For more information, see Associating Future Virtual Machine Memory Allocations with a NUMA Node on page 422.

Automatic NUMA Optimizations

By default, ESX Server balances virtual machines and their related data between the available NUMA nodes. ESX Server attempts to maximize use of "local memory," that lies on the same NUMA node as the virtual machine that is running.

ESX Server automatically assigns each virtual machine to a temporary "home" NUMA node. The virtual machine only runs on CPUs in the home node, with access to its "local memory."

Periodically, ESX Server compares the utilization levels of all NUMA nodes and attempts to "rebalance" the nodes if one node has a higher utilization level than the other nodes. ESX Server rebalances the nodes by changing a virtual machine's "home" NUMA node from the overutilized node to an underutilized node.

When the NUMA nodes are balanced, ESX Server again attempts to maximize use of "local memory." For additional information on this process refer to the `numa` man page.

You may also set affinity manually as described in the next section. If you do so, then ESX Server won't automatically rebalance the nodes, and you must balance the NUMA nodes to avoid overloading any single node.

Manual NUMA Optimizations

If you have applications that use a lot of memory or have a small number of virtual machines, then you may want to optimize performance by setting your NUMA optimizations manually. However, for most users, ESX Server's automatic NUMA optimizations, as described in the previous section, should provide you with good performance.

There are two NUMA options you may set manually:

- CPU affinity — See the following section.
- Memory affinity — See Associating Future Virtual Machine Memory Allocations with a NUMA Node on page 422.

Typically, to bind a virtual machine to a NUMA node, you should set the virtual machine's CPU affinity to use only the CPUs on the desired node, and set the NUMA memory affinity to the same node.

Note: If you set these optimizations manually, then ESX Server does not automatically "rebalance" the nodes if one node becomes overloaded. You must balance the NUMA nodes to avoid overloading any single NUMA node.

Associating Virtual Machines to a Single NUMA Node

You can improve the performance of the applications on a virtual machine by associating it to the CPU numbers on a single NUMA node (manual CPU affinity). (See NUMA Configuration Information on page 418 for information on obtaining these CPU numbers.)

- VMware Management Interface — Associate a virtual machine to a single NUMA node. Click **Edit** in the **Scheduling Affinity** section of the CPU page for the virtual machine. Then click the appropriate choices next to **Run on Processor(s)** and **Do not Run on Processor(s)**. Click **OK**.

  See Managing CPU Resources from the Management Interface on page 394 for additional information.

- Virtual machine configuration file — Add the following:

  `sched.cpu.affinity = <set>`

  where `<set>` comprises CPU numbers on a single NUMA node. This entry binds all virtual CPUs in this virtual machine to the NUMA node.

  For example, typing `sched.cpu.affinity = 4,5,6,7` binds this virtual machine to the NUMA node that has physical CPUs 4 through 7.

  See Editing the Virtual Machine Configuration File on page 395 for additional information on this entry.

- `procfs` interface on the service console

  `/proc/vmware/vm/<id>/cpu/affinity`

  Write a comma-separated list of the CPU numbers on a single NUMA node. See Using procfs on page 397 for additional information on this entry.

Note: If you manually set CPU affinity by one of the preceding options, then ESX Server automatically sets the virtual machine's memory to be allocated on the same NUMA node. If you want to disable this feature, you need to change the `NUMAAutoMemAffinity` configuration option to 0 (zero). For more information on changing this advanced option, see Changing Advanced Settings on page 219.

Associating Future Virtual Machine Memory Allocations with a NUMA Node

You can also improve performance by specifying that all future memory allocations on a virtual machine use pages associated with a single NUMA node (manual memory affinity). When the virtual machine uses "local" memory, the performance improves on this virtual machine. (See Obtaining NUMA Statistics on page 418 to determine the NUMA node number.)

Note: You should specify nodes to be used for future memory allocations only if you have also specified CPU affinity. If you make manual changes only to the memory affinity settings, automatic NUMA rebalancing will not work properly.

Do one of the following:

- VMware Management Interface — Associate a virtual machine to a single NUMA node. Click **Edit** in the **Memory Affinity** section of the Memory page for the virtual machine. Then click the appropriate choices next to the NUMA nodes. Click **OK**.

  See Managing Memory Resources from the Management Interface on page 410 for additional information.

- Virtual machine configuration file — Add the following:

  ```
  sched.mem.affinity = <NUMA_node>
  ```

  where `<NUMA_node>` is the number of a single NUMA node.

- `procfs` interface on the service console:

  ```
  /proc/vmware/vm/<id>/mem/affinity
  ```

  Write the number of the NUMA node.

Example of Binding a Virtual Machine to a Single NUMA Node on an 8-way Server

The following example illustrates manually binding four CPUs to a single NUMA node for a virtual machine. In the example, we want this virtual machine to run only on node 1.

An example output of `cat /proc/vmware/NUMA/hardware` is:

```
System type : IBM x440-compatible
# NUMA Nodes : 2
Total memory : 14336 MB
Node   ID        MachineMem    ManagedMem  CPUs
0      00        4096 MB       1210 MB     0 1 2 3
1      01        10240 MB      6143 MB     4 5 6 7
```

The CPUs — for example, 4, 5, 6 and 7 — are the physical CPU numbers.

1. Complete one of the following to bind a two-way virtual machine to use only the last four physical CPUs of an eight-processor machine:
   - Add the following in the virtual machine's configuration file.

     ```
     sched.cpu.affinity = 4,5,6,7
     ```

   - In the VMware Management Interface, associate a virtual machine to a single NUMA node by checking the appropriate boxes next to **Run on Processor(s)** in the CPU tab of the virtual machine details page.
2. Set the virtual machine's memory affinity to specify that all of the virtual machine's memory should be allocated on node 1.
   - Add the following in the virtual machine's configuration file.

     ```
     sched.mem.affinity = 1
     ```

Completing these two steps ensure that the virtual machine runs only on NUMA node 1 and, when possible, allocates memory from the same node.

Sizing Memory on the Server

These guidelines are intended to help system administrators determine an appropriate amount of hardware memory for running a virtual machine workload on ESX Server 2.1. Since the characteristics of your particular workload also influence memory needs, you should follow up with testing to confirm that memory sizes computed according to these guidelines achieve the desired results.

ESX Server uses a small amount of memory for its own virtualization layer, additional memory for the service console and all remaining memory for running virtual machines. The sections below explain each of these uses and provide a quantitative sizing example.

Server Memory

ESX Server 2.1 uses approximately 24MB of system memory for its own virtualization layer. This memory is allocated automatically when the ESX Server is loaded and is not configurable.

Service Console Memory

The recommended amount of memory to configure for the service console varies between 192MB and 512MB, depending on the number of virtual machines you plan to run concurrently on the server:

- 192MB for <= 8 virtual machines
- 272MB for <= 16 virtual machines
- 384MB for <= 32 virtual machines
- 512MB for > 32 virtual machines

Virtual Machine Memory Pool

The remaining pool of system memory is used for running virtual machines. ESX Server manages the allocation of this memory to virtual machines automatically based on administrative parameters and system load. ESX Server also attempts to keep some memory free at all times in order to handle dynamic allocation requests efficiently. ESX Server sets this level at approximately 6 percent of the memory available for running virtual machines.

Virtual Machine Memory

Each virtual machine consumes memory based on its configured size, plus additional overhead memory for virtualization.

The dynamic memory allocation for a virtual machine is bounded by its minimum and maximum size parameters. The maximum size is the amount of memory configured for use by the guest operating system running in the virtual machine. By default, virtual machines operate at their maximum allocation, unless memory is overcommitted.

The minimum size is a guaranteed lower bound on the amount of memory that is allocated to the virtual machine, even when memory is overcommitted. The minimum size should be set to a level that ensures the virtual machine has sufficient memory to run efficiently, without excessive paging.

The maximum size can be set to a higher level to allow the virtual machine to take advantage of excess memory, when available.

Overhead memory includes space reserved for the virtual machine frame buffer and various virtualization data structures. A virtual machine configured with less than 512MB of memory requires 54MB of overhead memory for a single virtual CPU virtual machine, and 64 MB for a dual-virtual CPU SMP virtual machine. Larger virtual machines require an additional 32MB of overhead memory per additional gigabyte of configured main memory. For example, a single virtual CPU virtual machine with a configured maximum memory size of 2GB requires 102MB of overhead memory.

Memory Sharing

Many workloads present opportunities for sharing memory across virtual machines. For example, several virtual machines may be running instances of the same guest operating system, have the same applications or components loaded or contain common data. ESX Server uses a proprietary transparent page sharing technique to securely eliminate redundant copies of memory pages.

With memory sharing, a workload consisting of multiple virtual machines often consumes less memory than it would when running on physical machines. As a result, the system can support higher levels of overcommitment efficiently.

The amount of memory saved by memory sharing is highly dependent on workload characteristics. A workload consisting of many nearly-identical virtual machines may free up more than 30 percent of memory, while a more diverse workload may result in savings of less than 5 percent of memory.

To determine the effectiveness of memory sharing for a given workload, try running the workload, and observe the actual savings by looking at the output of the `/proc/vmware/mem` file.

ESX Server memory sharing runs as a background activity that scans for sharing opportunities over time. The amount of memory saved may vary over time; for a fairly constant workload, the amount generally increases slowly until all sharing opportunities are exploited.

Memory Overcommitment

In many consolidated workloads, it is rare for all virtual machines to be actively using all of their memory simultaneously. Typically, some virtual machines are lightly loaded, while others are more heavily loaded, and relative activity levels generally vary over time. In such cases, it may be reasonable to overcommit memory to reduce hardware memory requirements.

ESX Server automatically transfers memory from idle virtual machines to virtual machines that actively need more memory in order to improve memory utilization.

You may also specify configuration parameters to preferentially devote space to important virtual machines.

The minimum size for a virtual machine defines a guaranteed lower bound on the amount of memory that it is allocated, even when memory is overcommitted. You can also use memory shares to specify the relative importance of different virtual machines. In any case, you should configure an appropriate minimum size for each virtual machine to ensure that each virtual machine can function effectively (without excessive paging), even when all virtual machines are active concurrently.

When memory is scarce, ESX Server dynamically reclaims space from some virtual machines based on importance and current working sets. For optimal performance, the server attempts to reclaim memory from a virtual machine via a VMware-supplied `vmmemctl` module running in the guest. This allows the guest operating system to invoke its own native memory management policies, causing it to swap to its own virtual disk only when necessary.

ESX Server also has its own swap file and may also swap memory from a virtual machine to the ESX Server swap file directly, without any involvement by the guest operating system.

Example: Web Server Consolidation

Suppose that you are using ESX Server to consolidate eight nearly-identical Web servers running IIS on Windows 2000. Each Windows 2000 machine is configured with 512MB of memory. The native memory requirement with eight physical servers is 8 * 512MB = 4GB.

To consolidate these servers as virtual machines, 24MB is needed for the server virtualization layer and 192MB is recommended for the service console. Each virtual machine also requires an additional 54MB of overhead memory. An additional 6 percent should be added to account for the minimum free memory level. Assuming no overcommitment and no benefits from memory sharing, the memory required for virtualizing the workload is 24MB + 192MB + (1.06 * 8 * (512MB + 54MB)) = 5016MB. The total overhead for virtualization in this case is 920MB.

If memory sharing achieves a 10 percent savings (410MB), the total memory overhead drops to only 510MB. If memory sharing achieves a 25 percent savings (1GB), the virtualized workload actually consumes 104MB less memory than it would on eight physical servers.

It may also make sense to overcommit memory. For example, suppose that on average, two of the eight Web server virtual machines are typically idle and that each Web server virtual machine requires only 256MB to provide minimally acceptable service. In this case, the hardware memory size can be reduced safely by an additional 2 * 256MB = 512MB. In the worst case where all virtual machines happen to be active at the same time, the system may need to swap some virtual machine memory to disk.

More Information

For additional background information on ESX Server memory usage, see Memory Resource Management on page 403.

Managing Network Bandwidth

VMware ESX Server supports network traffic shaping with the `nfshaper` loadable module. A loadable packet filter module defines a filter class; multiple filter instances may be active for each loaded class. The current release supports only one filter class — `nfshaper`, which is a transmit filter for outbound bandwidth management that can be attached to virtual machines using either a `procfs` interface on the service console or the VMware Management Interface.

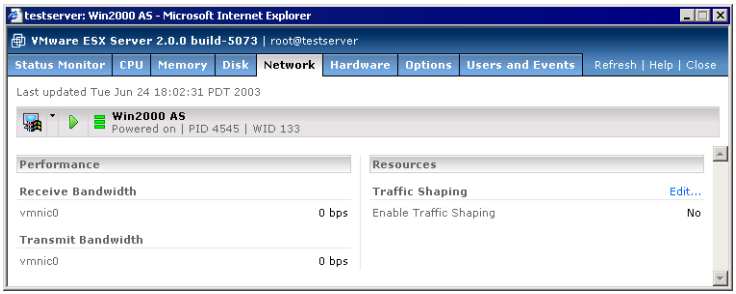
Using Network Filters

This section describes how to use the VMware Management Interface to attach and detach `nfshaper` and obtain statistics from it. It also describes how to attach, detach and query filter instances from the `procfs` interface on the service console.

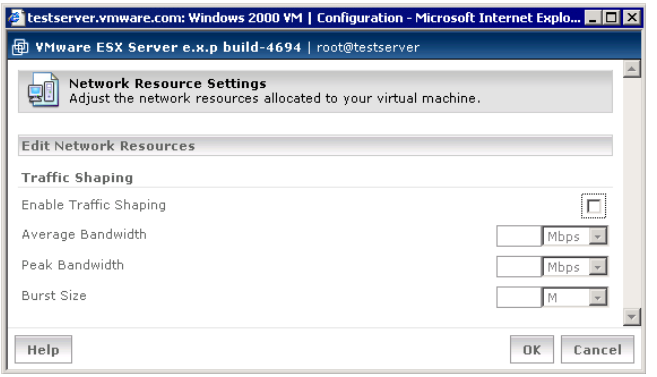
Managing Network Bandwidth from the Management Interface

You may view and change settings from the virtual machine details pages in the VMware Management Interface.

1. On the server's Status Monitor page, click the name of an individual virtual machine. The details page for that virtual machine appears.
2. Click the **Network** tab.



3. Click **Edit**. The Network Resource Settings page appears.



4. Enter the desired settings, then click **OK**. For information on these settings, see Configuring a Virtual Machine's Networking Settings on page 104.

You must log in as root in order to change resource management settings using either the management interface or `procfs`.

Managing Network Bandwidth from the Service Console

You must log in as root in order to change resource management settings using the `procfs` interface on the service console.

`/proc/vmware/filters/status`
This file contains network filtering status information, including a list of all available filter classes and, for each virtual machine with attached filters, its list of attached filter instances. Read the file with `cat` to see a quick report on network filtering status.

`/proc/vmware/filters/xmitpush`
Command file used to add a new transmit filter instance to a virtual machine. Writing `<id> <class> [<args>]` to this file attaches a new instance of filter `<class>` instantiated with `<args>` to the virtual machine identified by `<id>`.

`/proc/vmware/filters/xmitpop`
Command file used to detach a transmit filter from a virtual machine. Writing `<id>` to this file detaches the last filter attached to the virtual machine identified by `<id>`.

`/proc/vmware/filters/xmit`
This directory contains a file for each active filter instance. Each file named `<class.n>` corresponds to the `<n>`th instance of filter class `<class>`.

Reading from a file reports status information for the filter instance in a class-defined format. Writing to a file issues a command to the filter instance using a class-defined syntax.

Note: The current release allows only a single network packet filter to be attached to each virtual machine. Receive filters are not implemented in this release.

Traffic Shaping with nfshaper

As described in the preceding sections, you can manage network bandwidth allocation on a server from the VMware Management Interface or from the `procfs` interface on the service console.

The shaper implements a two-bucket composite traffic shaping algorithm. A first token bucket controls sustained average bandwidth and burstness. A second token bucket controls peak bandwidth during bursts. Each `nfshaper` instance can accept parameters to control average bps, peak bps and burst size.

The `procfs` interface, described in Using Network Filters on page 428, is used to attach an `nfshaper` instance to a virtual machine, detach an `nfshaper` instance from a virtual machine, query the status of an `nfshaper` instance or issue a dynamic command to an active `nfshaper` instance.

Service Console Commands

`config <bpsAverage> <bpsPeak> <burstSize> [<periodPeak>]`
Dynamically reconfigure the shaper to use the specified parameters: average bandwidth of `<bpsAverage>` bits per second, peak bandwidth of `<bpsPeak>` bits per second, maximum burst size of `<burstSize>` bytes and an optional peak bandwidth enforcement period `<periodPeak>` in milliseconds. Each parameter may optionally use the suffix k (1k = 1024) or m (1m = 1024k).

`maxq <nPackets>`
Dynamically set the maximum number of queued packets to `<nPackets>`.

`reset`
Dynamically reset shaper statistics.

Examples

Suppose that you want to attach a traffic shaper to limit the transmit bandwidth of the virtual machine with ID 104. To create and attach a new shaper instance, issue an `xmitpush` command as described in Managing Network Bandwidth from the Service Console on page 429. Note that root privileges are required to attach a filter.

```
echo "104 nfshaper 1m 2m 160k" > /proc/vmware/filters/
xmitpush
```

This attaches a traffic shaper with average bandwidth of 1Mbps, peak bandwidth of 2Mbps and maximum burst size of 160Kb.

To find the number of the attached `nfshaper` instance, query the network filtering status, which contains a list of all filters attached to virtual machines:

```
cat /proc/vmware/filters/status
```

Suppose the reported status information indicates that the filter attached to virtual machine 104 is `nfshaper.2.104`. The procfs node for this filter can be used to obtain status information:

```
cat /proc/vmware/filters/xmit/nfshaper.2.104
```

The same procfs node can also be used to issue commands supported by the `nfshaper` class. For example, you can dynamically adjust the bandwidth limits by issuing a `config` command:

```
echo "config 128k 256k 20k" > /proc/vmware/filters/xmit/
nfshaper.2.104
```

When a virtual machine is terminated, all attached network filters are automatically removed and destroyed. To manually remove a shaper instance you can issue an `xmitpop` command as described in Managing Network Bandwidth from the Service Console on page 429. Note that root privileges are required to detach a filter.

```
echo "104" > /proc/vmware/filters/xmitpop
```

Managing Disk Bandwidth

ESX Server provides dynamic control over the relative amount of disk bandwidth allocated to each virtual machine. You can control disk bandwidth separately for each physical disk or logical volume. The system manages the allocation of disk bandwidth to virtual machines automatically based on allocation parameters and system load. This is done in a way that maintains fairness and tries to maximize throughput.

You may specify initial disk bandwidth allocation values for a virtual machine in its configuration file. You may also modify disk bandwidth allocation parameters dynamically using the VMware Management Interface, the `procfs` interface on the service console or the VMware Scripting API.

Reasonable defaults are used automatically when you do not specify parameters explicitly. However, if you plan to run a virtual machine that will have disk-intensive workloads, such as a database, or file server, then you may want to increase its disk shares.

Information about current disk bandwidth allocations and other status is available via the management interface, the `procfs` interface on the service console and the VMware Scripting API.

Allocation Policy

ESX Server uses a modified proportional-share allocation policy for controlling disk bandwidth per virtual machine. This policy attempts to control the disk bandwidth used by a virtual machine to access a disk while also trying to maximize throughput to the disk.

Disk bandwidth shares entitle a virtual machine to a fraction of the bandwidth to a disk or LUN. For example, a virtual machine that has twice as many shares as another for a particular disk is entitled to consume twice as much bandwidth to the disk, provided that they are both actively issuing commands to the disk.

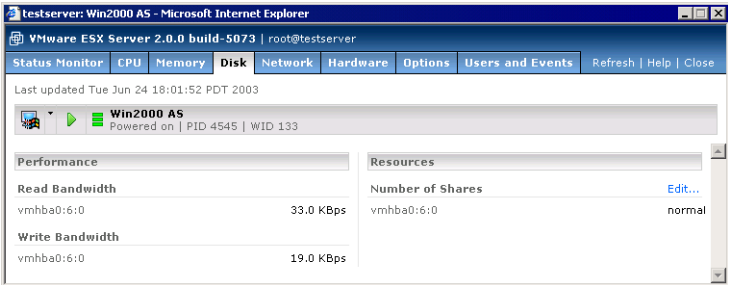
Bandwidth consumed by a virtual machine is represented in consumption units. Every SCSI command issued to the disk effectively consumes one unit by default and additional units proportional to the size of the data transfer associated with the command.

Throughput to the disk is maximized through the use of a scheduling quantum for disk requests from a virtual machine to a disk. A virtual machine is allowed to issue a number of requests to a disk (the scheduling quantum) without being preempted by another virtual machine. The issuing of a multiple requests without preemption is applicable only if these requests access sequential sectors on the disk.

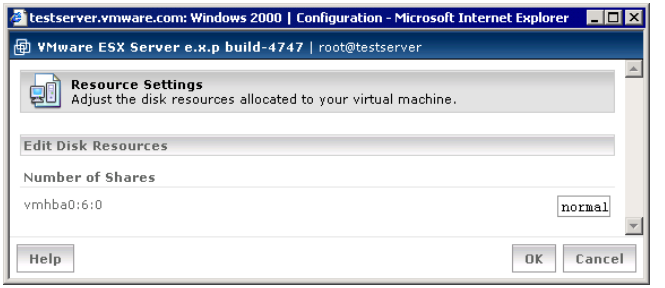
Managing Disk Bandwidth from the Management Interface

You may also view and change settings from the virtual machine details pages in the VMware Management Interface. To change disk bandwidth settings, you must be logged in as root and the virtual machine must be running.

1. On the server's Status Monitor page, click the name of an individual virtual machine. The details page for that virtual machine appears.
2. Click the **Disk** tab.



3. Click **Edit**. The Disk Resource Settings page appears.



4. Specify the shares value, then click **OK**.

Configuration File Options

You may edit the configuration file using a text editor on the service console or through the management interface.

To edit configurations parameters in the management interface, complete the following steps.

1. Click the arrow to the right of the terminal icon and select **Configure Options** in the Virtual Machine menu.
2. In the Options page, in the Verbose Options section, click **click here**.

3. Click **Add** to add a new configuration parameter or click in the text field to edit an existing parameter.
4. Click **OK**.

If you edit a virtual machine's configuration file by hand, use the following formats to control disk bandwidth allocation for the virtual machine.

```
scsi0:1.name = <fsname>:<diskname>.dsk
```

This is the standard format for specifying the VMFS file underlying a virtual disk.

```
sched.scsi0:1.shares = n
```

This configuration option specifies the initial disk bandwidth share allocation for a virtual machine for the disk `scsi0:1` to be `n` shares. The valid range of numerical values for `n` is `1` to `100000`. You may also use the special values **low**, **normal** and **high**. These values are automatically converted into numbers, through the configuration options `DiskSharesLow`, `DiskSharesNormal` and `DiskSharesHigh`, described in the next section. If the number of shares for a disk is not specified, the assigned allocation is **normal**, with a default value of `1000` shares.

Note: It is possible for a configuration file to have multiple lines specifying the number of shares. If this happens, the last value specified is used.

Configuration File Examples

```
scsi0.virtualdev = vmxbuslogic
scsi0:1.present = TRUE
scsi0:1.name = vmhba0:2:0:5:rh6.2.dsk
scsi0:1.mode = persistent
sched.scsi0:1.shares = high

scsi0:2.present = TRUE
scsi0:2.name = scratchfs:scratch1.dsk
sched.scsi0:2.shares = 800
```

In the example above, the first four lines in the first group and the first two lines in the second group are present in the configuration file before you make your changes. The final line in each group is the added line to specify the disk bandwidth allocation.

Managing Disk Bandwidth from the Service Console

Use the following guidelines for the service console commands to monitor and manage allocation of disk bandwidth on an ESX Server computer.

```
/proc/vmware/vm/<id>/disk/vmhba<x:y:z>
```

Reading from this file reports the number of disk bandwidth shares allocated to the virtual machine identified by `<id>` for the disk identified by `vmhba<x:y:z>`. It also reports disk usage statistics.

Writing a number `<n>` to this file changes the number of disk bandwidth shares allocated to the virtual machine identified by `<id>` to `<n>`. The valid range of values for `<n>` is `0` to `100000`. Or, you may use the special values **low**, **normal** and **high**. These values are automatically converted into numbers, through the configuration options `DiskSharesLow`, `DiskSharesNormal` and `DiskSharesHigh`, described in this section.

`/proc/vmware/config/DiskSchedNumReqOutstanding`
This option specifies the number of outstanding commands allowed to a disk when there are multiple virtual machines competing for bandwidth. The default value is `16`; the valid range of numeric values is from `1` to `256`. Note that selecting a number larger than `16` may affect the ability of ESX Server to provide fair allocation of disk bandwidth.

`/proc/vmware/config/DiskSchedQuantum`
This option specifies the number of sequential requests that a virtual machines may issue to a disk, without being preempted by another virtual machine. The default value is `8`; the valid range of numeric values is from `1` to `64`.

`/proc/vmware/config/DiskSharesLow`
This option specifies the a numerical value for the **low** shares value. By default, this number is `500`.

`/proc/vmware/config/DiskSharesNormal`
This option specifies the a numerical value for the **normal** shares value. By default, this number is `1000`.

`/proc/vmware/config/DiskSharesHigh`
This option specifies the a numerical value for the **high** shares value. By default, this number is `2000`.

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